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The Vegetation of Theodore Roosevelt National Park, North Dakota: A Habitat Type Classification

Paul L. Hansen, George R. Hoffman, and Ardell J. Bjugstad

Abstract

Vegetation of the Theodore Roosevelt National Park, North Dakota, was characterized according to habitat type based on concepts and methods developed by Daubenmire. Ten habitat types were described: seven—three grassland and four wooded types—occurred on upland plateaus, slopes, and relatively narrow benches along contours of the hills above the stream valleys; three—all wooded—occurred in valley bottoms. A key to identify the habitat types and discussion on the validation of the Habitat Type Classification and Species Diversity are provided.

Acknowledgements

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The Vegetation of Theodore Roosevelt National Park, North Dakota: A Habitat Type Classification

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Contents

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Increasing utilization of the northern Great Plains is reducing the areas of vegetation that are climax, or near-climax. Therefore, it becomes increasingly important to document in detail the vegetation characteristics of those areas currently free from, or only minimally disturbed by, human activities. Such areas are potentially valuable as reference areas against which to measure the impact of human activities. Theodore Roosevelt National Park (TRNP) in western North Dakota represents such a reference area, which also has a considerable diversity of habitats and vegetation types. This study documents the characteristics of pristine, or near-pristine, vegetation, and describes and delimits the habitat types (Daubenmire 1968) of TRNP. The information may be of interest to both those interested in basic ecological data and descriptions and those directly concerned with management of the vegetation described.

STUDY AREA

Physiography and Soils

Theodore Roosevelt National Park (TRNP) was established as a National Park in 1947. It covers 26,578 ha divided between the North and South Units (fig. 1). The area is part of the Missouri River Plateau and is unglaciated, except for a small portion of the North Unit, and even there, glacial deposits are not particularly evident. The substrates are stratified beds of soft shales, sandstones, and lignite of the Tertiary Tongue River Formation of the Fort Union Group (Laird 1950, 1956). These substrates have been severely dissected by the Little Missouri River and its tributaries, resulting in "badlands" topography of gullied ravines and valleys separated by interstream uplands of various dimensions, from large plateaus of many hectares to small buttes of erosion-resistant sandstone or scoria. Some of the buttes are 200 m above the valley floors. Exposed lignite has eroded along some of the steep hills, leaving resistant terraces paralleling the contours of the hills. At lower levels, just above the floodplains of the major streams, terraces of alluvium add another distinctive feature to the landscape. The region is physiographically complex, with various sites for the establishment and maintenance of vegetation types (fig. 2). The soils of TRNP are regosols belonging to the Bainville Series, developed from excessively drained, medium-textured, calcareous parent material (Omodt et al. 1968). A typical and obviously immature soil profile shows an A1 horizon overlying a C horizon. Textures range from loams to clay loams.

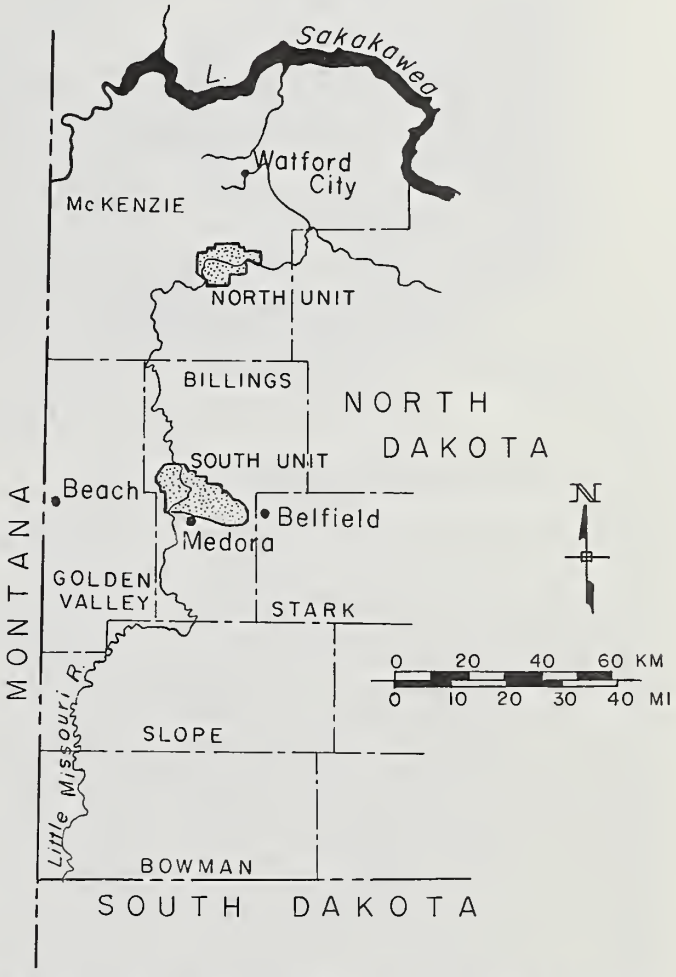

Figure 1.—Map of western North Dakota showing location of North and South Units of Theodore Roosevelt National Park.

Climate

The arid and continental climate of western North Dakota is characterized by long, cold winters and short, warm summers. The mean monthly low for January is −11.6°C, and the mean monthly high for July is 22.0°C. Most precipitation falls in early summer. June (the wettest month) precipitation ranges from mean 98.3 mm at Belfield to 83.6 mm at Medora (table 1). July means range from 72.6 mm at Belfield to 50.5 mm at Medora, illustrating the large decrease from June to July. The increase from May to June is equally impressive. Of the total precipitatin in the region recorded at weather stations, 75% falls from April through September.

Figure 2.—General view of the landscape at TRNP showing the badland topography.

ECOLOGIC TERMS AND CONCEPTS

The following terms and concepts are consistent with usage proposed by Daubenmire (1968) and used in previous studies of habitat types (Daubenmire and Daubenmire 1968; Daubenmire 1970; Hoffman and Alexander 1976, 1980; Pfister et al. 1977; Mueggler and Stewart 1980). "Climax vegetation" is that which has attained a steady-state with its environment, such that species successfully maintain their population sizes. "Habitat type" is defined as the land area which supports or can support the same primary climax vegetation (Daubenmire 1968). The climax vegetation is referred to as a plant association. As an example, the *Artemisia tridentata/Agropyron spicatum* habitat type of south-central Washington state supports the plant association of the same name, under pristine conditions. Grazing, however, can alter significantly the species composition such that a community of *Artemisia tridentata/Bromus tectorum* can result. If the same plant association were burned, killing *Artemisia tridentata,* and grazed, removing *Agropyron spicatum,* the resulting plant community might become a *Poa secunda/Bromus tectorum* community. The habitat type does not change as long as the habitats retain the capability of supporting the *Artemisia/Agropyron* association (Daubenmire 1970). On normal soils and topography, the climax vegetation is referred to as a "climatic climax." Where slope and soil exert predominant influence on the microclimate, compared to that of normal topography, the climax vegetation may reflect the altered microclimate in both composition and structure. Such self-perpetuating vegetation, if significantly different from that on normal soils and topography, is referred to as a "topographic climax" or an "edaphic climax" or in some cases a "topoedaphic climax," where both slope and soil are important in altering the climax vegetation. A "zootic climax" occurs where periodic grazing and trampling by domestic animals has altered the vegetation significantly. The altered vegetation maintains its composition and structure as a result of the kind and intensity of the periodic grazing. Seral vegetation is that which has not attained a steady-state with its environment. Ordinarily it follows a major disturbance.

Habitat types are defined to delimit and ecologically characterize land units of similar biotic potential, which makes the concept valuable to both basic and applied science. Habitat types can be useful in predicting rates of tree growth, susceptibility of trees to insects and mistletoe infection, potential for producing browse after fire, depth of soil moisture penetration, drought during the summer, and successional trends after disturbance (Arno and Pfister 1977; Daubenmire 1961, 1972; Hoffman and Alexander 1980, 1983; Layser 1974; Mueggler and Stewart 1980; Pfister 1972). The present study can provide a basis for better understanding the effects of grazing on habitat types in western North Dakota.

PREVIOUS VEGETATION STUDIES

Previous vegetation studies in western North Dakota did not include attempts to delimit habitat types. Hanson and Whitman (1938) described nine major kinds of grassland vegetation, which they correlated with edaphic and topographic factors. At least three of their types were considered to be seral, and the status of some others was not given. Their *Bouteloua gracilis/Stipa comata/Carex filifolia* vegetation type on upland plateaus and gentle slopes, and the *Artemisia cana/Agropyron smithii* vegetation type of alluvial flats adjacent the Little Missouri River and its tributaries were considered to be stable types. The *Andropogon gerardii-*

Table 1.—Mean precipitation (P, in mm) and temperature (T, in °C) from selected weather stations near Theodore Roosevelt National Park

Month	Location							
	Beach		Belfield		Medora 3NNE		Watford City	
	P	*T*	*P*	*T*	*P*	*T*	*P*	*T*
Jan.	12.9	−11.1	15.7	−11.8	11.4	−11.9	14.5	−11.4
Feb.	10.4	−8.7	17.0	−8.4	12.7	−7.8	12.7	−9.4
Mar.	15.7	−2.9	22.1	−4.2	16.3	−3.3	19.8	−3.4
Apr.	30.5	5.5	32.5	5.1	25.9	5.7	34.0	6.1
May	55.4	11.7	55.9	11.9	44.2	12.6	48.0	12.9
June	90.2	16.8	98.3	16.3	83.6	17.2	86.9	17.3
July	44.2	20.9	72.6	20.1	50.5	21.2	52.6	21.8
Aug.	40.6	19.7	61.0	19.8	37.1	20.6	38.6	20.6
Sept.	31.5	13.8	30.7	13.6	30.7	14.1	33.3	14.4
Oct.	23.1	7.1	25.9	7.4	20.3	7.4	23.9	7.9
Nov.	12.7	−0.8	19.0	−1.6	14.2	−0.9	14.5	−1.7
Dec.	10.2	−7.2	8.6	−6.7	6.9	−6.9	13.2	−7.5
Annual[1]	377.4	5.4	459.3	5.1	353.8	5.7	392.0	5.7

[1] *Mean total annual precipitation.*

dominated type, much more restricted in distribution, also might have been stable (Hanson and Whitman 1938). Quinnild and Cosby (1958) found three apparently stable vegetation types on two ungrazed mesas in western North Dakota. The types were dominated by *Agropyron smithii, A. dasystachyum,* and *Stipa comata,* respectively. Larson and Whitman (1942) reported a vegetation type dominated by *Agropyron smithii, Bouteloua gracilis, Carex eleocharis,* and *C. filifolia* on an ungrazed mesa, in the badlands of South Dakota. From the badlands of southeastern Montana, Brown (1971) reported seven vegetation types dominated by the following: *Sarcobatus vermiculatus, Atriplex confertifolia/Artemisia tridentata, Artemisia tridentata/Atriplex confertifolia-Agropyron spicatum, Artemisia tridentata/Agropyron spicatum, Rhus trilobata/Agropyron spicatum, Juniperus scopulorum/Agropyron spicatum, Pinus ponderosa/Juniperus scopulorum.* The distribution of most of these vegetation types appeared to be controlled by specific soil and/or topographic characteristics. Ralston (1960) concluded that the lower temperatures and higher moisture levels of north-facing exposures at TRNP were primarily responsible for the success of *Juniperus scopulorum*-dominated vegetation there. Nelson (1961) described two additional forest types at TRNP, including a *Populus deltoides* vegetation type along streams, and a *Fraxinus pennsylvanica* vegetation type along streams and in upland ravines.

METHODS

The approach used follows that of Daubenmire and Daubenmire (1968) and Daubenmire (1970). Preliminary work at TRNP was done during the summer of 1978, by traveling extensively throughout the North and South Units, collecting plants and noting possible study sites. Stands of vegetation were sought that were nearly mature, most homogeneous, and least disturbed by fire, trails, past farming, or grazing. Homogeneity was an important criterion and was determined subjectively. Obvious discontinuities and sharp breaks in the microtopography of any stand, and locally disturbed areas, such as animal trails, were avoided. Areas in stands were chosen which appeared to have a representative expression of all vegetation layers present. From the 1978 field work, a tentative list was made of the habitat types to be substantiated or altered as a result of intensive sampling in 1979.

During the summer of 1979, 70 stands were intensively sampled. At each stand sampled, a rectangular plot 15 x 25 m was set up. If the plot was located on a slope, it was oriented with the long axis parallel to the contour to maximize the chance of remaining within the same soil type. In woodland stands, sample plots were selected to include the largest trees of the stand, provided the trees were not located near trails, ecotones, or other disturbances. With the largest trees possible in each 375-m^2 plot, the undergrowth vegetation and soil were most representative of the oldest part of the stand. Each plot was then subdivided into three 5 x 25 m macroplots. Within each 375-m^2 plot, all trees taller than 1 m were measured at breast height and were recorded in diameter size classes. Trees shorter than 1 m were counted in two 1 x 25 m strips along the sides of the central macroplot. In the calculation of tree basal areas, the midpoints of the diameter classes were used. Because the largest trees in the plots were included, the basal area calculation produced a higher basal area than would be expected for the average stand. The technique was used consistently throughout the study, so that the results could be compared from one stand to another.

In each stand sampled, canopy coverages were estimated for all undergrowth species within 50 2 x 5 dm microplots placed systematically along the sides of the central macroplot. The canopy coverage of each species was recorded as one of six coverage classes: 1 = <1–5%, 2 = 6–25%, 3 = 26–50%, 4 = 51–75%, 5 = 76–95%, 6 = 96–100% (Daubenmire 1959). Mosses and lichens were lumped together for coverage

estimates. Plant species in the 15 x 25 m plots which occurred in none of the 2 x 5 dm microplots were noted also.

In each stand, 25 samples of the upper decimeter of mineral soil were collected. The samples were air-dried in the field, then were composited for laboratory analysis. Soil passing through a 2–mm sieve was used to determine texture using a modified Bouyoucos method, pH using a combination electrode on the saturated soil paste, nitrogen by the Kjeldahl method, and organic matter by a modified Walkley-Black method (Moodie and Koehler 1975). Cation exchange capacity (C.E.C.), free lime, and extractable cations were determined using appropriate Hach Chemical test kits.

Nomenclature for plants collected in this study follows Van Bruggen (1976). Where possible, identification was carried out to the species level. Although plants were collected at various times during the growing season, there were some taxonomic difficulties related to the lack of flowering specimens or to the lack of clear taxonomic differences among certain species. As a result, the following were combined: (1) *Viola* spp., which includes *V. adunca, V. canadensis, V. nuttallii, V. pedatifida,* and *V. pratincola;* (2) Polypodiaceae, which includes *Cystopteris grafilis* and *Woodsia oregana;* (3) *Astragalus* sp., which is probably *A. adsurgens;* and (4) *Ribes setosum,* which could include *Ribes oxyacanthoides.* Voucher specimens collected in this study were deposited at TRNP and in the herbarium at the University of South Dakota.

HABITAT TYPE DESCRIPTIONS

Stipa comata/Carex filifolia Habitat Type

This habitat type occurs on upland plateaus and gentle slopes that appear to be free of excessive erosion (fig. 3). Seven stands were sampled; 49 species were recorded (table A1). *Stipa comata, Carex filifolia, Agropyron smithii, Koeleria pyramidata,* and *Selaginella densa* provide the greatest coverage (table A1). *Stipa comata* forms the dominant union (Daubenmire 1968) of this association. Its abundance and stature is usually indicative of the association. During years of low moisture, *Stipa comata* produces short plants with only a few flowering culms. Close inspection of the vegetation reveals a relatively complex structure, with grasses and broadleaf forbs forming a union under *Stipa. Agropyron smithii* dominates this union; other conspicuous members include *Koeleria pyramidata, Artemisia dracunculus, Chrysopsis villosa, Lactuca oblongifolia, Lygodesmia juncea,* and *Tragopogon dubius.* Another union of this association is dominated by *Carex filifolia,* which has 28.5% coverage. Other important species of this low-growing union are *Artemisia frigida, Carex eleocharis, Bouteloua gracilis,* and *Gaura coccinea.* This union provides 40–50% coverage wherever it occurs in the study region. Very close to the ground surface, and in places forming dense mats, is *Salaginella densa,* which provides 47.6% coverage in this association. Outside

Figure 3.—The *Stipa comata/Carex filifolia* habitat type occurs on uplands where the soil is deep and well-drained. The meter stick used for scale in this and subsequent photos is painted in decimeter segments.

this association, *Selaginella densa* occurs only rarely. The *Stipa/Carex* association is the apparent climatic climax of this study region.

Major species with their constancy and mean coverage percentages are the following:

Species	Constancy	Mean coverage
Stipa comata	100	39.4
Carex filifolia	100	28.5
Bouteloua gracilis	86	0.9
Carex eleocharis	100	1.3
Agropyron smithii	75	10.3
Koeleria pyramidata	100	9.7
Artemisia frigida	100	3.1
Gaura coccinea	86	0.7
Lactuca oblongifolia	86	4.0
Lygodesmia juncea	71	0.9
Tragopogon dubius	100	0.4
Selaginella densa	100	47.6
Artemisia dracunculus	100	2.7

Compared to some of the other habitat types, forbs are relatively more important, although graminoids provide the greatest coverage. Among the seven stands sampled, the mean coverages of graminoids, forbs, and shrubs are the following:

graminoids:	mean coverage = 90%;	S.E. = 9.46
forbs:	mean coverage = 62.4%;	S.E. = 7.82
shrubs:	mean coverage = 3.29%;	S.E. = 0.71.

Forb coverage is almost 70% that of the graminoids. Hanson and Whitman (1938) reported a community in western North Dakota dominated by *Bouteloua gracilis*, *Stipa comata*, and *Carex filifolia*. They suggested this community closely reflected the macroclimate of the region. Coupland (1950, 1961) described a *Stipa comata-Bouteloua gracilis* community in western Canada in which *Carex filifolia* is important and in which *Stipa comata* is a productive species. He reported *Carex filifolia* increases in abundance in a southerly direction from Canada, and with overgrazing, *Bouteloua gracilis* becomes a dominant species. Nelson (1961) reported that heavy grazing favors the "short" grasses over the "midgrasses." In the present study, *Bouteloua gracilis* contributed little to the total canopy coverage. Coupland (1950, 1961) also found *Selaginella densa* to be an important component of the *Stipa comata*-dominated community, and suggested that *Selaginella densa* increases with protection from grazing and decreases from trampling by grazing animals on some Canadian grasslands. Mueggler and Stewart (1980) reported a *Stipa comata/ Bouleloua gracilis* habitat type on alluvial substrates in southern Montana, mainly east of the Continental Divide. Their data suggest it is the most xeric steppe habitat type in western Montana. This habitat type has some similarities to the *Stipa/Carex* habitat type of TRNP, although the latter is considerably richer floristically.

Soils of this habitat type range from sandy loams to loamy sands. The high sand content of soils of *Stipa comata*-dominated vegetation corresponds to other findings (Coupland 1961, Daubenmire 1970, Dix 1960, Hanson 1935, Hanson and Whitman 1938, Lauenroth and Whitman 1977, and Wright and Wright 1948). Sandy soils in this climate have a high infiltration rate, deep penetration of water, and high moisture availability, but low moisture-holding capacity. The organic matter contents of these soils were lowest of all the soils in this study and may be related to coarse textures. They readily leach, have high oxidation rates, and possibly low productivity. Edaphic characteristics are given in Appendix 3.

Agropyron smithii/Carex filifolia Habitat Type

This habitat type occurs on slopes of 9% to 20%, and is characterized by the dominance of *Agropyron smithii* and *Carex filifolia* (fig. 4). In the nine stands sampled, only 32 species occurred, compared to 49 species of the *Stipa comata/Carex filifolia* habitat type (table A2). Constancy and mean coverage percentages of the major plants of the nine stands sampled are as follows:

Species	Constancy	Mean coverage
Agropyron smithii	100	91.2
Carex filifolia	78	14.0
Artemisia frigida	78	1.1
Tragopogon dubius	78	0.2
Stipa comata	67	1.2
Lactuca oblongifolia	56	0.4

Forbs are particularly underrepresented in this habitat type. The importance of graminoids in this habitat type may be illustrated by examining the total coverage provided compared to that of the forbs and shrubs. The mean total graminoid coverage of the nine stands sampled was 111.7% (S.E. = 4.01), and the mean total forb coverage in the same nine stands was 2.33% (S.E. = 0.91). Shrubs also provided little coverage in these stands; mean total shrub coverage was 1.44% (S.E. = 0.38).

The soils of this habitat type are fine-textured. Hanson and Whitman (1938) described a plant community in western North Dakota dominated by *Agropyron smithii*, *Bouteloua gracilis*, and *Carex filifolia*, which occurred on gradual slopes of heavy-textured soils. Quinnild and Cosby (1958) found vegetation of mesa tops in western North Dakota dominated by *Agropyron smithii*, *Agropyron dasystachyum*, *Stipa comata*, *Bouteloua gracilis* and *Artemisia frigida*. Larson and Whitman (1942) also reported on *Agropyron smithii*-dominated vegetation on mesas in the badlands of South Dakota. Their results suggest protection maintains a vegetation type dominated by *Agropyron smithii* and *Carex* sp., while combined mowing and grazing produces vegetation dominated by *Bouteloua gracilis*.

All surface soils of this habitat type were classified as loams; the clay content ranged from 14.0% to 24.4%. Fine-textured soils in this semiarid region have poor water balance conditions. This may account for the less

Figure 4.—Long slope of fine-textured soil which supports the *Agropyron smithii/Carex filifolia* habitat type.

rich assortment of species though *Agropyron smithii* is favored and often occurs in dense stands on heavy soils in this region (Weaver and Albertson 1956). The *Agropyron/Carex* association at TRNP is an edaphic climax.

Andropogon scoparius/Carex filifolia Habitat Type

Nine stands of this habitat type were sampled. A total of 66 species, including nine shrub species, were found. This habitat type is characterized by the dominance of *Andropogon scoparius* (fig. 5) with a mean coverage of 76.8% (table A3).

Characteristic species of this habitat type with constancy and mean coverage percentages are the following:

Species	Constancy	Mean coverage
Andropogon scoparius	100	78.8
Calamovilfa longifolia	100	5.3
Carex filifolia	100	8.8
Koeleria pyramidata	89	0.7
Echinacea angustifolia	89	0.6
Aster oblongifolius	89	0.4
Artemisia frigida	89	0.4
Helianthus rigidus	78	3.6
Lactuca oblongifolia	67	1.0
Gaura coccinea	67	0.5
Lygodesmia juncea	67	0.2

Although forbs provide limited coverage, there are numerous species which add considerable diversity to the vegetation of this habitat type. The mean coverages of graminoids, forbs, and shrubs in stands of this habitat type are as follows:

graminoids:	mean coverage = 97.4%;	S.E. = 2.86
forbs:	mean coverage = 7.78%;	S.E. = 2.59
shrubs:	mean coverage = 1.22%;	S.E. = 0.41.

Although more forb and shrub species are present in this habitat type, both life forms provide much less coverage than in the *Stipa/Carex* habitat type.

Because of the topographic position and the coarse-textured soils generally associated with the stands studied, the vegetation is considered to be a topoedaphic climax.

Hanson and Whitman (1938) described an *Andropogon scoparius*-dominated community on northerly slopes and where snow accumulates. They observed that *Andropogon* colonized bare areas created by step erosion. Once established, it spread and continued to dominate larger eroded areas, and its density and height made it an effective competitor with shorter species. The stands of *Andropogon/Carex* habitat type studied also may have become established after erosion. They appear to be permanent; there is no evidence other species are replacing the *Andropogon*. Redmann (1975) described a community dominated by *Andropogon scoparius*. His stands were on north-facing slopes, and both *Helianthus rigidus* and *Rosa arkansana* were important species.

Figure 5.—Well-developed stand of *Andropogon scoparius/Carex filifolia* association.

Both Hanson and Whitman (1938) and Redmann (1975) observed small stands of *Andropogon gerardii*-dominated vegetation. The present study also found small stands of vegetation, usually on steep south-facing slopes and primarily in the North Unit. These stands are small and are not considered sufficiently large to sample or to classify as a habitat type.

Soils of this habitat type have high sand and low clay contents. In three of the stands studied, soils had considerable gravel, from 7% to 36% by weight. In the South Unit of TRNP, the five stands sampled were on soils rich in gravel or scoria, on slopes ranging from 18% to 42%. In the North Unit of TRNP, this habitat type is restricted primarily to the glaciated areas north of the Missouri River, though a few stands were observed south of the River, in the Achenbach Hills region. Stands 22, 23, and 24 had gravel ranging from 6.7% to 36.2% of the soil dry weight. Edaphic characteristics are given in Appendix 3.

Juniperus horizontalis/Andropogon scoparius Habitat Type

Five stands of this vegetation were sampled; all are in the South Unit of the Park and on slopes exceeding 28%. This habitat type is distinguished by the dominance of *Juniperus horizontalis*, with a mean coverage of 80.4%, and the presence of the *Andropogon scoparius* union (fig. 6). The *Carex filifolia* union is also represented (table A4). In the stands sampled, there were 60 species, 43 of which also occur in the *A. scoparius/C. filifolia* habitat type (table A4). Based on a floristic comparison, the *Andropogon/Carex* and *Juniperus/Andropogon* habitat types are 68% similar. Ten shrub species occur in the *Juniperus/Andropogon* habitat type, although the coverage of *J. horizontalis* exceeds considerably the combined coverage of all the other shrubs. Stand 10 was richest with eight shrub species, including *J. horizontalis*, *Artemisia cana*, *Potentilla fruticosa*, *Prunus virginiana*, *Rhus aromatica*, *Rosa arkansana*, *Shepherdia argentea*, and *Symphoricarpos occidentalis*. There, the coverage of *J. horizontalis* was 83%, and the total coverage of the remaining seven shrubs was 30%. This habitat type is rather localized in its distribution. On the basis of topographic and edaphic factors, vegetation of this habitat type is a topoedaphic climax. Major species with their constancy and mean coverage percentages in this association are as follows:

Species	Constancy	Mean coverage
Juniperus horizontalis	100	80.4
Andropogon scoparius	100	24.2
Calamovilfa longifolia	100	7.0
Carex filifolia	100	3.0
Campanula rotundifolia	100	1.1
Petalostemon purpureum	100	0.6
Galium boreale	80	4.8
Anemone patens	80	2.4
Potentilla fruticosa	80	2.4
Gaura coccinea	80	0.6
Echinacea angustifolia	80	0.5
Linem perenne	80	0.3
Senecio plattensis	80	0.2

Figure 6.—*Juniperus horizontalis/Andropogon scoparius* habitat type. The low-growing *Juniperus* is evident as a low growing, darker plant in this photo. Scattered culms of *Andropogon* are also conspicuous.

Of these 13 species with high constancies, only five have 67% or higher constancies in the *Andropogon/Carex* association. Comparing the lists of species with high constancy values for the *Andropogon/Carex* and *Juniperus/Andropogon* associations, the floristic similarity is only 38%, considerably lower than the similarity based on the total species lists of both associations. Coupland (1961) reported *J. horizontalis* on exposed sites in the Great Sand Hills, Alberta. Quinnild and Cosby (1958) found it on eroded edges of a mesa in western North Dakota. Whitman and Hanson (1939) described a community on scoria buttes in North Dakota, in which both *J. horizontalis* and *Mentzelia decapetala* were dominant. Redmann (1975) observed occasional mats of *J. horizontalis* on sandy soil in western North Dakota. At TRNP, stands of *J. horizontalis* appear to be stable, and habitat type status is assigned to these sites. Edaphic characteristics of this habitat type are listed in Appendix 3.

Artemisia tridentata/Agropyron smithii Habitat Type

This habitat type occurs on terraces or narrow benches that parallel the contours of hills 10 to 60 m above the valley floor of the Little Missouri River and its principal tributaries (fig. 7). In the four stands of this vegetation, only 29 species were found. *Artemisia tridentata* is dominant, and both the *Agropyron smithii* and *Carex filifolia* unions are represented (table A5). There are nine shrub species, but the coverage of *A. tridentata* far exceeds the combined coverage of the remaining eight shrubs. *Atriplex confertifolia* is second, with slightly less than 2% mean coverage. The paucity of species reflects the severity of the habitats supporting this vegetation, which is also a topoedaphic climax. Major species of this association and their constancy and mean coverage percentages are as follows:

Species	Constancy	Mean coverage
Artemisia tridentata	100	29.7
Agropyron smithii	100	68.8
Agropyron caninum	100	8.1
Opuntia polyacantha	100	0.4
Atriplex confertifolia	75	1.5
Carex filifolia	50	3.2

All species of the four stands studied are listed in table A5. Shrubs and graminoids are most conspicuous in this habitat type; forbs are sparse. The mean coverages of shrubs, graminoids, and forbs are as follows:

shrubs:	mean coverage = 33.5%;	S.E. = 4.35
graminoids:	mean coverage = 83.0%;	S.E. = 8.83
forbs:	mean coverage = 3.5%;	S.E. = 1.71.

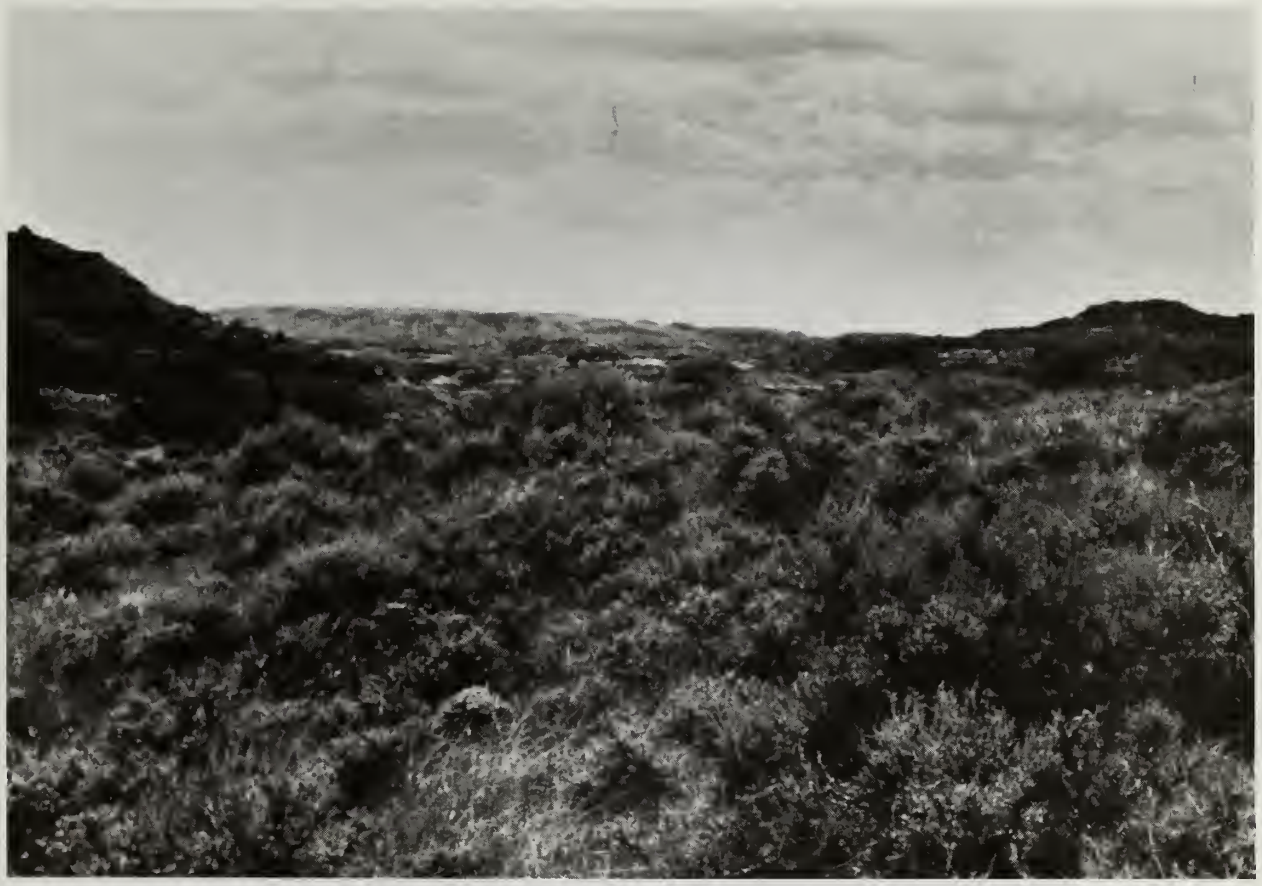

Figure 7.—*Artemisia tridentata/Agropyron smithii* habitat type This habitat type occurs on narrow benches or terraces along the contours of the hills.

Edaphic characteristics of the four stands studied are listed in Appendix 3.

Other descriptions of *Artemisia tridentata*-dominated vegetation of western North Dakota and eastern Montana indicate broad similarities in composition and habitat conditions (Brown 1971, Hazlett and Hoffman 1975, Whitman and Hanson 1939). In the Missouri River "breaks" region of Montana, Mackie (1970) described an *Artemisia tridentata/Agropyron smithii* association as an edaphic climax on "shallow, gravelly, or claypan surface soils."

In his study of badland vegetation in southeastern Montana, Brown (1971) described a community dominated by *Artemisia tridentata*, with *Atriplex confertifolia* and *Agropyron spicatum* as codominants. *Agropyron smithii* was present in small patches.

Artemisia cana/Agropyron smithii Habitat Type

This habitat type occurs on large areas of floodplains and river terraces adjacent the Little Missouri River and its tributaries, areas commonly referred to as "sagebrush flats" (fig. 8). The dominant is *Artemisia cana*, with a mean coverage of 33.6% (table A6). Between widely spaced shrubs, numerous other species occur in one or two lower unions dominated by *Agropyron smithii* and *Carex filifolia*. Although 55 species occurred in the 12 stands sampled, only seven have a constancy of 50% or higher. Major species of this association and their constancy and mean coverage percentages are as follows:

Species	Constancy	Mean coverage
Artemisia cana	100	33.6
Agropyron smithii	100	70.9
Stipa viridula	75	2.4
Agropyron caninum	67	6.6
Artemisia frigida	58	0.6

As in the *Artemisia tridentata/Agropyron smithii* habitat type, graminoids in this habitat type provide considerably more coverage than either forbs or shrubs. The total forb and shrub coverage in this habitat type, however, is greater than in the *A. tridentata/A. smithii* habitat type. The means for this habitat type are the following:

shrubs:	mean coverage = 54.1%;	S.E. = 7.69
graminoids:	mean coverage = 84.8%;	S.E. = 5.32
forbs:	mean coverage = 9.4%;	S.E. = 2.27.

Floristically, this habitat type is only 47% similar to that of the *A. tridentata/A. smithii* habitat type. *Symphoricarpos occidentalis* occurs in five of the stands sampled; its mean coverage is 47%. Clones of this species are described in detail later. *Agropyron caninum* and *Muhlenbergia cuspidata* reach their maximum abundance in this and the *A. tridentata/A. smithii* habitat type.

Figure 8a.—*Artemisia cana/Agropyron smithii* habitat type. The relatively wide spacing of *Artemisia* and nearly complete herbaceous cover is evident in this photo.

Figure 8b.—Broad level deposit of alluvium support *Artemisia cana*-dominated vegetation. These areas are referred to as "sagebrush flats."

This vegetation is heavily utilized by bison and deer in TRNP. Nelson (1961) suggested that heavy grazing of this vegetation reduces the amounts of *A. smithii* and *Stipa viridula* in favor of *Bouteloua gracilis*. Hanson and Whitman (1938) suggested that occasional flooding and deposition of alluvium might prevent short grasses from becoming important in this vegetation. *A. cana* provides fall and winter browse for game animals and, outside TRNP, for livestock (Johnson and Nichols 1970).

The substrates vary considerably with respect to drainage and texture, and have moderate salt content (Hanson and Whitman 1938). The *A. cana/A. smithii* association is an edaphic climax in this region.

This is an important habitat type, covering large areas. Outside the Park, grazing animals utilize it heavily, and ungrazed stands of the habitat type inside the Park become even more valuable as reference areas. Edaphic characteristics are listed in Appendix 3.

Fraxinus pennsylvanica/Symphoricarpos occidentalis Habitat Type

In the arid northern Great Plains, woodland vegetation is confined to habitats where adequate soil moisture, along streams or in other favorable topographic positions, compensates for the arid climate (fig. 9). The *F. pennsylvanica/S. occidentalis* association is an edaphic climax on the floodplain adjacent the Little Missouri River and its major tributaries. Tree population data for this habitat type are given in Appendix 2. *Populus deltoides* currently dominates many of the stands but is no longer reproducing. The data indicate it will be replaced by *Fraxinus pennsylvanica*. Tree basal areas of the stands studied range from 23.3 m^2/ha to 63.1 m^2/ha (Appendix 2) The larger trees, some 6–7 dm d.b.h., are *Populus deltoides*, but the young trees establishing in the stands are *Fraxinus pennsylvanica*. *Juniperus scopulorum* is tallied with the tree species in the data, although it is an understory species in the closed forest. Its current abundance is attributed to adequate light penetrating to the shrub and herb layers of the community as a result of wide spacing of the old *Populus*. Along the Missouri River, in central North Dakota (Burgess et al. 1973), in southeastern South Dakota (Wilson 1970), and near Omaha, Nebr. (Vaubel 1975), *Populus deltoides* is a pioneer species, and is replaced successionally by various combinations of *Fraxinus*, *Ulmus*, *Acer*, and *Celtis*. The *F. pennsylvanica/S. occidentalis* habitat type is recognized by the combination of tree and undergrowth unions. *F. pennsylvanica* is present in the understory, although the overstory may be dominated currently by the non-reproducing *Populus deltoides*. The undergrowth is dominated by the *Sym-*

Figure 9.—The *Fraxinus pennsylvanica/Symphoricarpos occidentalis* habitat type is confined in this semiarid climate to relatively narrow bands paralleling larger streams. Along a meander of the Little Missouri River, shown here, *Populus deltoides* became established in rows parallel to the stream course.

phoricarpos occidentalis union with S. occidentalis, Rhus aromatica, Toxicodendron rydbergii, and other shrubs well-represented (fig. 10). Among the grasses, Calamovilfa longifolia, Elymus canadensis, and Muhlenbergia racemosa are important (table A7). In the four stands sampled, there are 52 undergrowth species. Major undergrowth species of the stands sampled and their constancy and mean coverage percentages are as follows:

Species	Constancy	Mean coverage
Symphoricarpos occidentalis	100	40.5
Toxicodendron rydbergii	100	23.0
Melilotus officinalis	100	28.8
Elymus canadensis	100	11.5
Muhlenbergia racemosa	100	8.3
Melilotus albus	100	7.0
Rhus aromatica	100	5.4
Agropyron caninum	100	4.0
Smilacina stellata	100	0.9
Parthenocissus vitacea	100	0.6
Poa pratensis	75	37.2

The importance of shrubs, graminoids, and forbs may be shown by their mean coverage values:

shrubs:	mean coverage = 76.8%;	S.E. = 23.2
graminoids:	mean coverage = 64.2%;	S.E. = 27.0
forbs:	mean coverage = 43.5%;	S.E. = 15.8.

Symphoricarpos and *Toxicodendron* together provide 63.5% coverage among the shrubs.

Before TRNP excluded cattle, grazing was common in these streamside forests. Currently, in TRNP, bison sometimes utilize this habitat type for grazing, watering, and the shade provided during the summer. The importance of certain alien species attests to the heavy usage earlier by cattle, and the considerable usage by bison now that the area is a National Park. The most important grass is *Poa pratensis*, with a mean coverage of 36.2%. The most important forb is *Melilotus officinalis*, with a mean coverage of 28.8%. Edaphic characteristics of stands sampled are listed in Appendix 3.

Fraxinus pennsylvanica/Prunus virginiana Habitat Type

This habitat type occurs in ravines or draws or on moderately steep north-facing slopes throughout much of TRNP. It is recognized by the presence of *Fraxinus pennsylvanica* as the dominant species, with *Ulmus americana* as a codominant in some of the stands. Both species reproduce successfully in this habitat type. In V-shaped ravines, largest *Fraxinus* occur near the center, or bottom, of the stand, where there is greater soil moisture. Tree basal area of the stands studied ranged from 21.6 m^2/ha to 35.9 m^2/ha (Appendix 2). The largest tree sampled was a *Fraxinus*, with 116 xylem rings at breast height. The average age of the *Fraxinus*

Figure 10.—Interior of a stand of the *Fraxinus pennsylvanica/Symphoricarpos occidentalis* habitat type. The undergrowth here is a rich mixture of both shrubs and herbaceous species, with *Fraxinus* seedlings obvious in the foreground.

was 60–70 years. Heart rot prevented determining the age of some of the larger *Fraxinus*. *Ulmus americana* is important in some stands, and *Acer negundo* and *Juniperus scopulorum* also occur in this habitat type. The undergrowth is dominated by *Prunus virginiana*, 2–3 m tall, with a mean coverage of 27.7% (fig. 11). This shrub reaches its greatest density near the edge of these stands, where light intensity is greater, and it often forms a fringe beyond the stand margin. The smaller *Symphoricarpos occidentalis* and *Rosa woodsii* are also important shrubs in the undergrowth (table A7). The important graminoids of this habitat type are *Carex sprengelii*, with a mean coverage of 61.1%, and *Elymus virginicus*, with a mean coverage of 27.5%. These two species reach their maximum importance in this habitat type. Owing to heavy utilization by cattle in the past, and possibly as a result of bison use currently, *Poa pratensis* and *Taraxacum officinale* are both important in this habitat type. Tree seedlings and saplings are abundant; trampling by bison apparently is not an important factor at present. *Galium boreale*, with a mean coverage of 10.2%, is the most important forb. Other forbs characteristic of this habitat type include *Monarda fistulosa*, *Thalictrum dasycarpum*, *T. venulosum*, *Sanicula marilandica*, *Arctium minus*, and *Ranunculus arbortivus*. In the four stands sampled, 51 species were found. The vegetation appears to be a topographic climax. Important undergrowth species in stands of this habitat type and their constancy and mean coverage percentages are as follows:

Species	Constancy	Mean coverage
Prunus virginiana	100	27.7
Symphoricarpos occidentalis	100	12.1
Elymus virginicus	100	27.5
Galium boreale	100	10.2
Carex sprengelii	50	30.6
Poa pratensis	75	15.6

Mean coverages for shrubs, graminoids, and forbs are as follows:

shrubs:	mean coverage = 46.2%;	S.E. = 14.0
graminoids:	mean coverage = 82.2%;	S.E. = 19.0
forbs:	mean coverage = 29.0%;	S.E. = 11.6.

Compared to the *Fraxinus/Symphoricarpos* habitat type, graminoids provide greater coverage, but both shrubs and forbs provide less coverage. Overall, the total mean undergrowth coverage is 157.4% for the *Fraxinus/Prunus* habitat type, compared to 184.5% for the *Fraxinus/Symphoricarpos* habitat type. Stands of this habitat type are important deer habitats, providing both browse and shelter. Stands also attract domestic grazing animals outside the boundary of TRNP. Lack of tree

Figure 11.— *Fraxinus pennsylvanica/Prunus virginiana* habitat type. Photo taken from the edge of the stand. *P. virginiana* dominates the undergrowth.

reproduction in such stands have concerned other investigators (Boldt et al. 1978, Severson and Boldt 1978). It appears from their studies, and also from results of a study in the Custer National Forest, that cattle grazing and trampling is the most important single cause of failure of trees to successfully replace themselves in these wooded draws. The stands in TRNP become all the more important, therefore, as reference areas with which to compare changes resulting from domestic animal activity outside the Park. Even within the Park, considerable variation in undergrowth vegetation among stands of this habitat type reflect the effects of grazing before the area was a national park.

Edaphic characteristics of stands of this habitat type are given in Appendix 3.

Populus tremuloides/Betula occidentalis Habitat Type

This habitat type occurs on upper slopes facing northwest to east (fig. 12). Stands of the *Fraxinus/Prunus* habitat type are lower on the same slopes. The habitat type is not widespread in TRNP, and is recognized by the dominance of *Populus tremuloides*. The vegetation is also a topographic climax. The undergrowth is dominated by *Betula occidentalis*, with a mean coverage of 22.1%, *Prunus virginiana*, with a mean coverage of 31.1%, and *Symphoricarpos albus*, with a mean coverage of 20.5%. *S. occidentalis* and *Toxicodendron rydbergii* are also important undergrowth shrubs in this habitat type. *Carex sprengelii*, *Oryzopsis micrantha*, and *Apocynum androsaemifolium* are major herbaceous species in this habitat type, with *Disporum trachycarpum*, *Galium boreale*, and *Smilacina stellata* also important. In the four stands sampled, 57 species were encountered (table A7). Mean basal area of trees in stands sampled is 24.6 m^2/ha. The largest size class represented among the tree species is 2–3 dm d.b.h. The largest *Populus*, based on xylem layers at breast height, ranged from 43 to 77 years. Major undergrowth species in stands of this habitat type and their constancy and mean coverage percentages are as follows:

Species	Constancy	Mean coverage
Betula occidentalis	100	22.1
Prunus virginiana	100	31.1
Toxicodendron rydbergii	100	22.7
Disporum trachycarpum	100	5.4
Smilacina stellata	100	3.6
Galium boreale	100	5.0
Apocynum androsaemifolium	75	11.4

Graminoids provided less coverage in this habitat type than in any other habitat type studied. Mean coverages for shrubs, graminoids, and forbs in stands sampled are as follows:

Figure 12.—*Populus tremuloides/Betula occidentalis* habitat type. Undergrowth is a rich mixture of shrubs and forbs primarily.

shrubs:	mean coverage = 91.5%;	S.E. = 14.2
graminoids:	mean coverage = 20.8%;	S.E. = 9.1
forbs:	mean coverage = 43.2%;	S.E. = 8.9.

Shrub coverage is higher than that of other habitat types, and forb coverage is the same as that of the *Fraxinus/Symphoricarpos* habitat type but higher than that of the *Fraxinus/Prunus* habitat type. There is a 46% floristic similarity between stands of this habitat type and those of the *Fraxinus/Prunus* habitat type. The *Fraxinus/Prunus* and *Populus/Betula* habitat types are in relatively close proximity; and although they share nearly half their species, the two habitat types are distinct and can be separated on the basis of critical overstory and undergrowth species.

As shown in Appendix 2, the tree stratum in stands of this habitat type has six species, although seldom do all occur in the same stand. Both *P. tremuloides* and *F. pennsylvanica* have population structures indicating successfully reproducing species that could maintain or increase their population sizes. *Fraxinus* is currently a codominant in this habitat type; but it may become a more important species in the future. A constant source of seeds is available from lower slope stands of the *Fraxinus/Prunus* habitat type. Edaphic characteristics are given in Appendix 3.

Juniperus scopulorum/Oryzopsis micrantha Habitat Type

This habitat type occurs on northwest to north-facing slopes of 35–70% and is recognized by the dominance of *J. scopulorum;* the vegetation is a topographic climax. Stands of this habitat type ordinarily cover entire hillsides in TRNP, making them quite distinct even from a distance (fig. 13). Principal shrubs are *Prunus virginiana, Symphoricarpos occidentalis,* and *Rhus aromatica;* their abundance relates positively with openings among the dominant *Juniperus. Oryzopsis micrantha* dominates the undergrowth and is also characteristic of this habitat type. Mosses and lichens cover about 72% of the ground surface (table A8). In the seven stands of this habitat type sampled, 52 species occurred.

Major undergrowth species in stands of this habitat type and their constancy and mean coverage percentages are as follows:

Species	Constancy	Mean coverage
Oryzopsis micrantha	100	66.9
Mosses and Lichens	100	72.3
Galium boreale	100	4.5
Rhus aromatica	100	4.2
Symphoricarpos occidentalis	100	1.7
Campanula rotundifolia	100	1.0
Prunus virginiana	86	10.5

Mean coverages provided by all shrubs, graminoids, and forbs are the following:

shrubs:	mean coverage = 17.4%;	S.E. = 7.76
graminoids:	mean coverage = 69.1%;	S.E. = 3.72
forbs:	mean coverage = 9.4%;	S.E. = 1.77.

The mean forb coverage is calculated without the moss and lichen coverage. Shrubs are not as important in this association as in the other forest associations of TRNP. The undergrowth is dominated by herbaceous species primarily.

Fraxinus pennsylvanica is present in most of the stands; but most are seedlings which grow in slight depressions where soil moisture exceeds normal for this habitat type. There is no evidence at present to suggest that *Fraxinus* will replace *Juniperus scopulorum* as the climax dominant. The largest *Juniperus* sampled are in the 3–4–dm d.b.h. size class (appendix 2). Occasionally, larger ones are observed. Many of the trees have more than 125 xylem layers, and some have more than 250. Tree basal areas for the stands sampled ranged from 22.1 m^2/ha to 29.6 m^2/ha. Before TRNP was established, the primary use made of these stands was the harvest of *Juniperus* for use as fence posts (Ralston 1960). Limited cattle grazing occurred, although game species used the stands extensively. Deer still utilize stands of this habitat type quite extensively. There are numerous game trails over much of the area of this habitat type; *Achillea millefolium* is most abundant along these trails. The physiognomy of these stands is similar to that of the pinyon-juniper stands of the Southwest, although pine is absent. Edaphic characteristics are given in Appendix 3.

Symphoricarpos occidentalis Community

This community occurs as scattered thickets over much of the study area. It is recognized by the dominance of *Symphoricarpos occidentalis* which forms dense thickets a few to several meters across (fig. 14). Observations suggest that these thickets may be long-lived seral communities (associes) occurring in at least two habitat types in TRNP. Typically, the community has three layers, an upper layer 0.5–1.0 m tall dominated by *Symphoricarpos occidentalis* and *Rosa woodsii,* an intermediate layer 0.2–1.5 m tall dominated by *Agropyron smithii, A. caninum, Lactuca oblongifolia,* and *Poa pratensis,* and a lower layer 0.1–0.3 m tall dominated by *Achillea millefolium, Artemisia ludoviciana,* and *Galium boreale.* In some of the larger, more complex thickets, there is a fourth taller layer dominated by *Prunus virginiana,* 2–3 m tall, with *Ribes odoratum* and *Rosa woodsii.* A total of 37 species occur in the five stands sampled. Most of the forbs grow near the margins of the thickets, where the shrubs are less dense. *Artemisia ludoviciana* and *Parietaria pennsylvanica* reach their maximum coverage and constancy in this community.

Symphoricarpos occidentalis thickets at TRNP occur on various exposures and substrates, from fine-textured alluvial soils of the *Artemisia cana/Agropyron smithii* habitat type to the coarse, gravelly substrates of the *Andropogon scoparius/Carex filifolia* habitat type. They also occur near margins of *Fraxinus*-dominated habitat types described above.

Symphoricarpos thickets also have been described in steppe vegetation elsewhere (Daubenmire 1970, Mackie 1970).

Figure 13a—Stand of *Juniperus scopulorum/Oryzopsis micrantha* habitat type on north-facing slope.

Figure 13b.—Interior of stand of *Juniperus/Oryzopsis* association showing the characteristically dense vegetation.

Figure 14.—Dense thicket of *Symphoricarpos occidentalis* with others in the background.

KEY TO THE HABITAT TYPES

1. Tree species absent
   2. Herbaceous species dominant
      3. *Stipa Comata* well represented: *Agropyron smithii* and/or *Andropogon scoparius* inconspicuous or absent .... *Stipa comata/Carex filifolia* habitat type.
      3. *Agropyron smithii* and/or *Andropogon scoparius* dominant; *Stipa comata* inconspicuous or absent.
         4. *Agropyron smithii* abundant; *Andropogon scoparius* absent ..... *Agropyron smithii/ Carex filifolia* habitat type.
         4. *Andropogon scoparius* abundant .... *Andropogon scoparius/ Carex filifolia* habitat type.
   2. Shrub species dominant
      5. *Artemisia tridentata* or *A. cana* present and conspicuous.
         6. *Artemisia tridentata* dominant; *Artemisia cana* absent ..... *Artemisia tridentata/ Agropyron smithii* habitat type.
         6. *Artemisia cana* dominant; *Artemisia tridentata* absent ..... *Artemisia cana/ Agropyron smithii* habitat type.
      5. *Artemisia tridentata* and *A. cana* absent or inconspicuous.
         7. *Juniperus horizontalis* principal shrub; *Symphoricarpos occidentalis* if present is widely scattered and drawfed .... *Juniperus horizontalis/ Andropogon scoparius* habitat type.
         7. *Symphoricarpos occidentalis* forming dense thickets or clones up to 1 m or more in height ..... *Symphoricarpos occidentalis* community type.
1. Tree species present and dominant
   8. *Populus deltoides* and/or *Fraxinus pennsylvanica* dominant or exhibiting adequate reproduction to become dominant.
      9. Undergrowth dominated by *Prunus virginiana*... ..... *Fraxinus pennsylvanica/Prunus virginiana* habitat type.
      9. Undergrowth dominated by *Symphoricarpos occidentalis; Prunus virginiana* absent or inconspicuous ..... *Fraxinus pennsylvanica/ Symphoricarpos occidentalis* habitat type.
   8. *Populus deltoides* and/or *Fraxinus pennsylvanica* absent or present in seedling and sapling size only.
      10. *Populus tremuloides* dominant; *Juniperus scopulorum* absent or rare..... ..... *Populus tremuloides/Betula occidentalis* habitat type.
      10. *Juniperus scopulorum* dominant; *Populus tremuloides* absent ..... *Juniperus scopulorum/Oryzopsis micrantha* habitat type.

DISCUSSION

Validation of the Habitat Type Classification

Natural vegetation is a convenient characteristic of the landscape to use in a classification scheme; the more mature the vegetation is, the more closely it reflects the biotic potential of the landscape (Daubenmire 1976).

A classification scheme provides a systematic ordering of the landscape units under study. In this case, the units are the habitat types, and the manner of delimiting these provides as natural a classification as possible. Because a habitat type consists of land units representing areas of similar environment, other research efforts can be related to the habitat types. For example, wildlife utilization (Mackie 1970), small mammal distributions (Hoffman 1960, Rickard 1957), growth rates of ponderosa pine (Daubenmire 1961), depth of soil moisture drying (Daubenmire 1972), and productivity and grazing potentials (Bjugstad and Whitman 1970, Mueggler and Stewart 1980), can be related to the habitat types to provide a means of correlating and communicating research results. Silvicultural and watershed management implications also have been discussed in relation to habitat types (Hoffman and Alexander 1976, 1980, 1983).

Species Diversity

Species diversity may be described as the median number of species occurring in areas of constant sampling size (Daubenmire 1970). Species diversity of the habitat types encountered in this study is shown in table 2. Among the steppe habitat types, diversity ranged from a low of 10 in the *Agropyron smithii/Carex filifolia* habitat type to a high of 29 in the *Juniperus horizontalis/Andropogon scoparius* habitat type. Four of the five stands sampled of the *Juniperus/Andropogon* habitat type are on north-facing slopes, with reduced solar insolation. This may be an important factor in influencing species diversity in the semi-arid climate of western North Dakota. Among the edaphic characteristics measured, surface soils of this habitat type are similar to those of the *Andropogon scoparius/Carex filifolia* and *Agropyron smithii/Carex filifolia* habitat types, the latter of which had the lowest median species diversity. The low species diversity of the *Agropyron/Carex* habitat type is possibly related to the very high coverage of *Agropyron* (table A2). Shantz (1924) described dense, almost pure stands of *Agropyron smithii*, accompanied by a paucity of forbs in west-central South Dakota. Possibly the density of the *Agropyron* sod inhibits the successful establishment of numerous other species.

Species diversity among habitat types dominated by tree species ranged from 21 in the *Juniperus scopulorum/Oryzopsis micrantha* habitat type to 30 in the *Populus tremuloides/Betula occidentalis* habitat type, which included six tree species. The remaining two habitat types dominated by trees had 29 species each. The generally higher numbers of species in the tree-dominated habitat types probably reflects the wetter conditions compared to the steppe vegetation of TRNP.

Table 2.—Species diversity in habitat types of Theodore Roosevelt National Park

Habitat type	No. of stands studied	Median no. of shrub, graminoid, and forb species per H.T.[1]	Total tree species per H.T.[2]
Stipa comata/Carex filifolia	7	23	
Agropyron smithii/Carex filifolia	9	10	
Andropogon scoparius/Carex filifolia	9	22	
Juniperus horizontalis/Andropogon scoparius	5	29	
Artemisia tridentata/Agropyron smithii	4	14	
Artemisia cana/Agropyron smithii	12	13	
Fraxinus pennsylvanica/Symphoricarpos occidentalis	4	26	3
Fraxinus pennsylvanica/Prunus virginiana	4	25	4
Populus tremuloides/Betula occidentalis	4	24	6
Juniperus scopulorum/Oryzopsis micrantha	7	19	2
Symphoricarpos occidentalis community type	5	15	

[1] *Based on fifty 0.1 m² microplots, per stand.*
[2] *Based on 375 m² per stand.*

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APPENDIX 1. HABITAT TYPE TABLES WITH STAND DATA

In the plant data, the number to the left of the dot is percent coverage where the value exceeds 0.5%, with a + to the left of dot indicating coverage of 0.5% or less. Number to the right of dot is percent frequency. Species present in the macroplot but not in the microplots are indicated by an asterisk (*). Stand numbers, locations, and topographic positions are also given.

Table A1.—*Stipa comata/Carex filifolia* habitat type

	Stand number						
	27	35	36	39	40	56	61
Location							
Quarter section	**NW**	**SW**	**SE**	**NW**	**NE**	**SW**	**NW**
Section	**16**	**2**	**3**	**11**	**11**	**24**	**32**
Township	**140N**	**140N**	**140N**	**140N**	**140N**	**148N**	**148N**
Range	**102W**	**101W**	**101W**	**101W**	**101W**	**100W**	**100W**
Topographic position							
Slope (%)	**0**	**0**	**0**	**4**	**8**	**18**	**3**
Aspect (°)	**0**	**0**	**0**	**270**	**292**	**178**	**269**
Elevation (m)	**823**	**823**	**835**	**823**	**826**	**750**	**774**
	Coverage/Frequency						
SHRUBS							
Artemisia cana	.	.	+.2	.	.	.	.
Artemisia frigida	1.4	4.52	3.34	1.12	3.40	5.60	6.60
Yucca glauca	.	.	.	.	+.2	.	.
GRAMINOIDS							
Agropyron caninum	.	.	.	+.2	.	.	+.6
Agropyron smithii	68.98	1.12	+.8	1.18	2.6	.	.
Andropogon scoparius	.	1.4	.	.	.	.	.
Aristida longiseta	+.2	.	.	.	.	.	.
Bouteloua gracilis	.	1.20	2.24	+.2	2.18	+.8	1.6
Bromus tectorum	.	.	1.4	.	.	.	.
Calmovilfa longifolia	.	.	.	+.2	.	1.4	.
Carex eleocharis	4.26	1.22	1.28	2.28	1.14	+.8	+.6
Carex filifolia	48.99	24.84	37.98	15.80	22.76	49.99	4.36
Koeleria pyramidata	3.28	10.72	13.84	5.58	14.66	8.38	15.94
Poa interior	.	+.8	+.8	.	.	.	+.2
Stipa comata	11.64	41.94	52.99	65.99	35.88	35.98	35.98
FORBS							
Artemisia campestris	.	+.2	.	.	.	.	+.6
Artemisia dracunculus	5.22	4.34	1.28	+.4	5.42	3.32	1.6
Aster oblongifolius	.	.	.	.	.	+.2	.
Astragalus crassicarpus	.	.	.	+.2	.	.	.
Astragalus lotiflorus	.	.	+.2	.	.	.	.
Chenopodium album	.	.	+.2	.	.	.	.
Coryphantha vivipara	.	.	.	.	+.2	.	.
Chrysopsis villosa	.	6.32	1.14	2.4	2.24	.	14.64
Echinacea angustifolia	.	.	.	.	.	.	+.2
Eriogonum flavum	.	.	.	.	.	.	+.2
Erysimum asperum	.	+.2	+.2	.	.	.	.
Gaura coccinea	2.26	+.2	.	1.4	1.6	1.6	+.8
Gentianella amarella	.	.	.	.	.	.	+.2
Helianthus rigidus	.	.	.	.	.	1.6	.
Lactuca oblongifolia	1.20	6.78	3.42	2.44	8.82	8.76	.
Liatris punctata	.	+.8	+.10	+.8	.	+.2	1.12
Linum perenne	.	.	.	+.8	.	.	.
Linum rigidum	.	.	.	.	.	+.8	.
Lithospermum incisum	.	1.36	1.36	1.40	1.30	+.2	.
Lygodesmia juncea	.	2.40	1.40	+.18	1.32	2.24	.
Melilotus officinalis	.	+.4	.	.	.	.	.
Opuntia polyacantha	.	+.2	.	1.14	+.2	+.2	.
Oxytropis lambertii	1.10	+.2	.	.	.	.	7.70
Petalostemon purpureum	.	.	+.2	.	.	.	+.6
Polygala alba	.	.	.	.	.	+.6	+.2
Potentilla pensylvanica	.	+.2	.	.	+.4	+.4	.
Psoralea argophylla	4.44	+.6	.	+.2	+.18	+.8	.
Ratibida columnifera	1.8	+.2	.	.	.	+.2	.
Selaginella densa	39.92	43.92	43.99	54.90	42.88	28.96	84.99
Sphaeralcea coccinea	+.2	.	.	.	.	.	.
Thermopsis rhombifolia		.	.	.	+.4	.	.
Tragopogon dubius	+.12	+.6	+.4	+.8	+.8	1.10	+.2
Vicia americana	.	.	.	+.16	.	.	.
Zigadenus venenosus	.	+.8	+.8	+.8	+.6	+.6	+.2
Species in microplots	16	27	23	24	22	24	22
Coverage of shrubs	1	4	3	1	3	5	6
Coverage of graminoids	134	79	106	88	76	96	55
Coverage of forbs	53	62	50	61	60	44	107
Total coverage	188	145	159	150	139	145	168

Table A2.—*Agropyron smithii/Carex filifolia* habitat type

	Stand number								
	3	5	14	18	20	21	43	54	62
Location									
Quarter section	**SE**	**SE**	**SE**	**SE**	**SE**	**NW**	**NW**	**NE**	**NE**
Section	**1**	**1**	**12**	**28**	**28**	**34**	**33**	**26**	**32**
Township	**140N**	**140N**	**140N**	**141N**	**141N**	**141N**	**148N**	**148N**	**148N**
Range	**102W**	**102W**	**102W**	**101W**	**101W**	**101W**	**99W**	**100W**	**99W**
Topographic position									
Slope (%)	**16**	**19**	**16**	**18**	**18**	**20**	**14**	**9**	**14**
Aspect (°)	**203**	**202**	**43**	**233**	**137**	**211**	**163**	**357**	**124**
Elevation (m)	**701**	**719**	**707**	**732**	**713**	**719**	**631**	**750**	**643**
	Coverage/Frequency								
SHRUBS									
Artemisia cana	.	.	.	.	.	.	+.4	.	.
Artemisia frigida	+.4	+.6	.	2.20	.	3.26	1.10	3.18	1.4
Atriplex nuttallii	+.2	.	.	.	.	.	.	.	.
Ceratoides lanata	+.4	2.6	.	.	1.4	.	.	.	.
GRAMINOIDS									
Agropyron smithii	93.99	92.99	98.99	86.99	91.99	82.99	93.99	96.99	91.99
Aristida longiseta	.	.	.	.	.	1.4	.	.	.
Bouteloua gracilis	.	.	.	.	.	10.42	2.24	.	16.36
Carex eleocharis	.	.	.	.	.	.	.	1.4	.
Carex filifolia	28.62	.	.	27.72	29.84	17.64	1.4	24.94	+.2
Koeleria pyramidata	.	.	.	+.2	.	.	.	3.30	+.2
Stipa comata	.	.	.	3.16	4.34	2.16	1.20	+.2	+.2
Stipa viridula	3.12	4.14	.	3.14	.	.	.	.	4.22
FORBS									
Achillea millefolium	.	.	.	.	.	.	.	+.8	.
Arabis holboellii	.	.	.	.	.	+.4	.	.	.
Artemisia dracunculus	.	.	.	.	.	.	.	+.2	.
Conyza canadensis	.	.	.	.	.	.	6.44	.	.
Coryphantha vivipara	+.2	.	.	.	.	.	+.2	.	.
Euphorbia podperae	+.2	.	.	.	.	.	.	.	.
Gaura coccinea	.	.	.	.	.	.	+.6	.	.
Hedeoma hispida	+.2	.	.	.	.	.	.	.	.
Lactuca oblongifolia	1.10	+.8	.	1.22	.	.	1.4	+.4	.
Linum perenne	.	.	+.2	+.2	.	.	.	.	.
Melilotus officinalis	.	.	.	.	.	.	.	.	+.6
Mosses & Lichens	2.28	+.2	.	+.2	.	.	.	1.4	.
Opuntia polyacantha	.	.	.	.	.	.	+.2	.	.
Plantago patagonica	.	.	.	.	.	.	2.32	.	.
Polygala alba	.	.	.	.	1.14	2.14	.	.	.
Ratibida columnifera	.	.	.	.	1.12	1.16	.	+.10	.
Selaginella densa	.	.	.	.	+.6	.	.	.	.
Senecio plattensis	.	.	.	.	+.4	+.4	.	.	.
Sphaeralcea coccinea	+.6	2.34	.	.	.	+.6	.	.	.
Taraxacum officinale	.	.	.	.	.	.	.	.	+.2
Tragopogon dubius	.	+.8	.	+.2	+.4	+.6	+.2	+.2	+.4
Species in microplots[1]	12	8	2	10	9	12	13	12	10
Coverage of shrubs	0	2	0	2	1	3	1	3	1
Coverage of graminoids	124	96	98	119	124	112	97	124	111
Coverage of forbs	3	2	0	1	2	3	9	1	0
Total coverage	127	100	98	122	127	118	107	128	112

[1]*Mosses and lichens are counted as one species in the total list.*

Table A3.—*Andropogon scoparius/Carex filifolia* habitat type

	Stand number								
	8	15	22	23	24	46	55	63	64
Location									
Quarter section	**SE**	**NE**	**SE**	**SE**	**NW**	**SE**	**NE**	**NE**	**NE**
Section	**28**	**13**	**35**	**35**	**4**	**29**	**26**	**28**	**28**
Township	**141N**	**140N**	**141N**	**141N**	**140N**	**147N**	**148N**	**148N**	**148N**
Range	**101W**	**102W**	**101W**	**101W**	**101W**	**100W**	**100W**	**100W**	**100W**
Topographic position									
Slope (%)	**27**	**18**	**28**	**30**	**42**	**13**	**6**	**16**	**0**
Aspect (°)	**271**	**242**	**70**	**205**	**195**	**300**	**193**	**179**	**0**
Elevation (m)	**738**	**738**	**747**	**747**	**747**	**725**	**744**	**716**	**719**
	Coverage/Frequency								
SHRUBS									
Artemisia cana	.	.	.	3.14	.	.	.	.	.
Artemisia frigida	+.8	2.28	+.2	+.4	+.4	+.2	+.2	.	+.10
Ceratoides lanata	.	.	.	.	+.2	.	.	.	.
Gutierrezia sarothrae	.	.	+.2	.	.	.	.	.	.
Juniperus horizontalis	1.4	.	.	.	.	+.2	.	.	.
Rhus aromatica	.	.	1.4	.	.	.	.	.	.
Rosa arkansana	+.10	+.2	+.6	.	.	1.16	.	.	+.6
Shepherdia argentea	.	.	.	.	.	.	.	.	+.2
Symphoricarpos occidentalis	.	.	3.2	.	.	.	.	.	.
Yucca glauca	.	+.2	.	.	.	.	+.12	.	.
GRAMINOIDS									
Agropyron smithii	.	.	+.4	+.8	.	.	+.2	.	.
Andropogon scoparius	68.99	88.99	88.99	72.98	65.99	84.99	70.98	77.99	81.99
Bouteloua curtipendula	.	.	3.16	14.44	19.80	.	+.2	3.12	.
Bouteloua gracilis	.	.	.	.	1.10	.	+.4	+.2	.
Calamovilfa longifolia	6.30	+.4	4.32	14.42	8.34	+.2	14.74	+.4	1.12
Carex filifolia	8.40	9.58	2.18	13.54	9.48	12.56	10.52	8.60	10.72
Carex sprengelii	4.44	.	.	.	.	.	.	.	.
Koeleria pyramidata	+.2	+.8	1.18	.	+.2	1.10	2.22	1.10	1.14
Muhlenbergia cuspidata	.	.	.	.	.	+.2	1.8	.	.
Stipa comata	+.2	.	+.2	3.18	1.6	.	.	+.4	.
FORBS									
Agoseris glauca	.	.	+.2	.	.	.	.	.	.
Anemone cylindrica	.	.	.	.	.	+.6	.	.	+.2
Anemone patens	1.18	+.4	.	.	.	.	.	.	.
Antennaria parviflora	+.4	1.20	+.2	.	.	.	.	.	.
Antennaria rosea	+.4	.	.	.	.	+.2	.	.	.
Arabis holboellii	.	+.2	.	.	.	.	.	.	+.2
Artemisia dracunculus	.	+.4	.	.	.	.	.	.	.
Aster laevis	.	.	.	.	.	+.4	.	.	.
Aster oblongifolius	1.26	1.8	+.4	.	+.4	+.8	+.8	+.12	+.6
Astragalus adsurgens	.	.	+.10	.	.	.	.	.	.
Astragalus crassicarpus	.	+.2	.	.	.	.	.	.	.
Astragalus gilviflorus	.	.	.	.	.	+.4	.	.	.
Calylophus serrulatus	+.4	+.2	+.2	.	.	.	.	.	.
Campanula rotundifolia	+.6	+.2	+.2	.	.	+.2	.	.	.
Castilleja sessiliflora	.	.	+.2	.	.	.	.	.	.
Chrysopsis villosa	.	+.2	.	.	.	.	.	.	.
Cirsium undulatum	.	.	.	.	1.4	.	.	.	.
Echinacea angustifolia	2.34	+.6	1.12	.	+.8	+.8	+.14	1.26	+.12
Erigeron strigosus	.	.	+.2	.	.	+.10	+.2	.	.
Galium boreale	.	.	+.2	.	.	.	.	.	.
Gaura coccinea	1.14	+.4	+.2	+.4	.	.	2.36	1.22	.
Glycyrrhiza lepidota	.	.	.	.	.	.	.	1.14	.
Hedeoma hispida	.	.	.	.	1.10	.	.	.	.
Helianthus rigidus	3.20	+.4	7.52	.	.	7.66	7.86	2.56	6.70
Lactuca oblongifolia	2.26	+.12	.	2.36	4.58	1.30	.	+.2	.
Liatris punctata	.	.	.	.	.	+.2	.	.	.
Linum perenne	+.6	+.2	+.6	.	.	.	.	.	.
Linum rigidum	.	.	.	.	+.2	.	.	.	.
Lithospermum incisum	.	.	.	.	.	.	.	.	+.2
Lygodesmia juncea	+.10	.	+.2	.	+.8	+.4	+.8	.	1.4
Medicago sativa	.	.	.	.	.	.	.	.	+.2
Melilotus officinalis	.	.	.	.	.	+.2	.	.	1.16
Mosses & Lichens	2.38	.	.	.	.	.	.	.	.
Opuntia fragilis	.	.	.	+.2	.	.	.	.	.
Opuntia polyacantha	.	+.4	+.4	.	.	.	.	.	.
Oxytropis lambertii	.	.	.	.	+.4	.	+.4	+.4	+.2
Petalostemon purpureum	+.6	.	+.2	.	.	.	.	.	+.2
Polygala alba	+.4	.	+.4	+.2	.	+.2	+.4	.	.
Potentilla arguta	.	.	+.4	+.2	.	.	.	.	.
Psoralea argophylla	.	.	.	2.16	2.34	.	1.48	.	+.8
Psoralea esculenta	.	+.2	.	.	.	.	+.2	+.2	.
Senecio plattensis	+.16	+.6	.	1.10	+.2	+.2	.	.	.
Solidago rigida	1.12	.	1.10	.	.	.	.	.	.
Sphaeralcea coccinea	.	.	+.8	+.4	1.10	.	.	.	.
Tragopogon dubius	.	+.2	.	.	+.2	.	.	.	.
Vicia americana	.	.	.	.	.	.	.	+.8	1.4
Species in microplots	26	25	32	15	22	23	20	16	20
Coverage of shrubs	1	2	4	3	0	1	0	0	0
Coverage of graminoids	86	97	98	116	103	97	97	89	94
Coverage of forbs	13	2	9	5	9	8	10	5	9
Total coverage	100	101	111	124	112	106	107	94	103

Table A4.—*Juniperus horizontalis/Andropogon scoparius* habitat type

	Stand number				
	9	10	12	44	47
Location					
Quarter section	**NE**	**SE**	**SW**	**NW**	**SE**
Section	**1**	**15**	**12**	**22**	**33**
Township	**140N**	**140N**	**140N**	**140N**	**148N**
Range	**102W**	**102W**	**102W**	**101W**	**99W**
Topographic position					
Slope (%)	**28**	**48**	**30**	**46**	**32**
Aspect (°)	**349**	**268**	**9**	**21**	**338**
Elevation (m)	**719**	**725**	**719**	**753**	**628**
	Coverage/Frequency				
SHRUBS					
Artemisia cana	.	3.4	.	.	.
Artemisia frigida	.	.	+.2	.	.
Juniperus communis	+.8	.	.	2.2	.
Juniperus horizontalis	61.92	82.99	85.99	85.98	90.99
Potentilla fruticosa	1.2	7.12	3.16	1.10	.
Prunus virginiana	.	2.8	.	.	.
Rhus aromatica	+.4	7.16	1.2	.	.
Rosa arkansana	+.2	+.8	+.2	.	.
Shepherdia argentea	.	1.2	.	.	.
Symphoricarpos occidentalis	.	7.60	2.36	+.4	.
GRAMINOIDS					
Agropyron caninum	.	.	.	+.4	+.2
Andropogon scoparius	36.92	25.80	24.84	35.84	2.6
Aristida longiseta	.	.	.	+.2	.
Bouteloua curtipendula	.	.	.	+.4	.
Calamovilfa longifolia	8.54	4.32	15.48	8.36	2.12
Carex filifolia	1.16	1.12	5.20	5.36	3.30
Carex sprengelii	+.6	1.16	.	.	.
Koeleria pyramidata	1.4	+.6	+.4	+.4	1.4
Muhlenbergia cuspidata	.	.	.	3.12	.
Stipa spartea	.	.	.	1.10	31.88
FORBS					
Achillea millefolium	.	+.12	+.2	.	.
Anemone cylindrica	.	.	.	1.42	.
Anemone patens	4.54	3.24	3.50	.	2.52
Antennaria parviflora	+.2	.	+.2	.	.
Antennaria rosea	.	.	.	+.2	+.2
Artemisia campestris	+.6	.	.	.	.
Aster falcatus	.	2.12	.	.	.
Aster laevis	+.2	.	.	+.16	2.28
Aster oblongifolius	1.12	.	+.2	.	+.4
Astragalus adsurgens	+.2	.	.	.	.
Astragalus gilviflorus	+.6	1.14	2.26	.	.
Astragalus sp.	.	.	1.4	.	.
Campanula rotundifolia	2.18	1.14	1.12	+.14	2.32
Chenopodium album	.	.	.	+.2	.
Echinacea angustifolia	+.14	1.14	1.18	.	+.2
Erigeron strigosus	.	.	.	.	+.8
Eriogonum flavum	+.4	.	.	.	.
Galium boreale	.	9.66	6.76	3.72	6.82
Gaura coccinea	1.6	1.10	+.14	.	1.22
Geum triflorum	.	.	.	.	+.2
Hedysarum boreale	12.40	.	.	.	.
Helianthus rigidus	2.24	+.4	+.8	.	.
Liatris punctata	+.10	+.2	.	.	.
Linum perenne	+.8	+.8	.	+.4	+.6
Linum rigidum	+.2	.	.	.	.
Lygodesmia juncea	1.10	.	+.8	.	.
Melilotus albus	.	.	.	.	+.2
Melilotus officinalis	.	.	.	1.4	4.26
Mosses & Lichens	+.4	1.10	1.10	.	.
Opuntia polyacantha	.	.	.	+.2	.
Oxytropis lambertii	+.4	.	.	+.2	+.8
Petalostemon purpureum	1.18	+.2	+.14	1.12	1.22
Polygala alba	+.4	.	+.2	.	.
Potentilla pensylvanica	.	.	1.2	.	.
Psoralea esculenta	+.4	.	+.2	.	.
Senecio plattensis	+.8	+.6	+.4	1.10	.
Solidago nemoralis	+.8	.	.	.	.
Solidago rigida	+.2	.	.	.	.
Thermopsis rhombifolia	1.18	+.2	.	.	.
Vicia americana	.	2.22	+.6	.	.
Viola sp.	.	.	.	.	+.2
Species in microplots	36	29	29	25	23
Coverage of shrubs	62	109	91	88	90
Coverage of graminoids	46	31	44	52	39
Coverage of forbs	25	21	16	7	18
Total coverage	133	161	151	147	147

Table A5.—*Artemisia tridentata/Agropyron smithii* habitat type

	Stand number			
	4	13	16	28
Location				
Quarter section	**SE**	**SW**	**SW**	**NW**
Section	**1**	**12**	**20**	**4**
Township	**140N**	**140N**	**140N**	**140N**
Range	**102W**	**102W**	**101W**	**101W**
Topographic position				
Slope (%)	**49**	**5**	**10**	**22**
Aspect (°)	**77**	**185**	**97**	**45**
Elevation (m)	**725**	**732**	**783**	**765**
	Coverage/Frequency			
SHRUBS				
Artemisia frigida	.	.	+.2	+.2
Artemisia tridentata	17.56	36.88	27.72	41.82
Atriplex confertifolia	4.14	.	2.2	+.2
Atriplex nuttallii	.	+.2	.	.
Ceratoides lanata	+.2	.	2.4	+.2
Eriogonum pauciflorum	.	.	.	+.2
Gutierrezia sarothrae	.	1.8	.	+.2
Ribes setosum	.	.	+.4	.
Symphoricarpos occidentalis	.	.	4.16	.
GRAMINOIDS				
Agropyron caninum	7.28	20.50	4.16	2.6
Agropyron smithii	64.99	45.90	86.98	81.99
Andropogon scoparius	+.2	.	.	.
Bouteloua gracilis	.	.	.	+.2
Carex filifolia	.	.	1.16	12.90
Muhlenbergia cuspidata	.	.	3.24	+.2
Koeleria pyramidata	.	.	.	3.6
Stipa viridula	.	.	1.4	3.14
FORBS				
Achillea millefolium	.	.	4.18	1.6
Astragalus agrestis	1.8	+.6	.	.
Gaura coccinea	.	.	.	+.2
Geum triflorum	.	+.4	.	.
Lactuca oblongifolia	+.6	.	2.30	+.4
Mosses & Lichens	+.2	.	.	.
Opuntia polyacantha	+.2	+.4	+.4	1.8
Parietaria pennsylvanica	.	.	2.10	.
Polygala alba	.	.	.	1.4
Ratibida columnifera	.	.	.	1.14
Sphaeralcea coccinea	+.2	+.2	.	.
Vicia americana	1.14	+.4	+.2	.
Species in microplots	12	10	16	19
Coverage of shrubs	21	37	35	41
Coverage of graminoids	71	65	95	101
Coverage of forbs	2	0	8	4
Total coverage	94	102	138	146

Table A6.—*Artemisia cana/Agropyron smithii* habitat type

	Stand number											
	1	6	7	26	66	69	70	2	25	31	32	65
Location												
Quarter section	SE	NW	NW	SE	NW	NW	NW	SE	NW	NE	SE	SW
Section	1	6	6	35	30	30	30	1	4	14	1	33
Township	140N	140N	140N	140N	148N	148N	148N	140N	140N	140N	140N	148N
Range	102W	101W	101W	101W	99W	99W	99W	102W	101W	102W	102W	99W
Topographic position												
Slope (%)	0	5	5	5	0	0	4	0	8	7	0	0
Aspect (°)	0	245	287	32	0	0	76	0	293	245	0	0
Elevation (m)	683	707	706	744	613	619	619	683	744	683	689	600
	Coverage/Frequency											
SHRUBS												
Artemisia cana	24.80	48.88	26.70	36.74	34.62	26.50	42.80	32.64	45.82	18.48	51.96	21.66
Artemisia frigida	.	+.2	+.2	+.4	.	.	.	.	3.6	+.6	1.8	3.16
Ceratoides lanata	.	4.14	1.2	+.4	.	.	.	.	2.8	.	.	.
Gutierrezia sarothrae	.	.	.	.	+.2	.	.	.	.	.	.	+.2
Rosa woodsii	.	.	.	.	.	.	.	.	.	.	.	1.2
Symphoricarpos occidentalis	.	.	.	.	.	.	.	63.82	24.48	61.72	13.26	70.88
GRAMINOIDS												
Agropyron caninum	.	+.4	2.10	4.10	.	.	.	7.20	3.8	23.72	13.32	27.54
Agropyron smithii	79.99	80.99	88.99	73.94	95.99	96.99	97.99	31.52	84.99	25.42	57.93	46.76
Bouteloua gracilis	.	.	.	.	.	.	+.8	.	.	.	.	.
Bromus inermis	.	.	.	.	.	.	.	.	.	.	1.2	.
Calamogrostis inexpansa	.	.	.	.	.	+.2	1.6	.	.	.	.	.
Calamovilfa longifolia	.	.	.	5.10	.	.	.	.	.	2.4	.	.
Carex filifolia	.	.	.	+.4	.	.	.	.	+.2	.	.	.
Distichlis spicata	.	.	.	.	.	+.2	.	.	5.10	.	.	.
Muhlenbergia cuspidata	.	.	.	5.12	.	.	.	.	.	.	.	.
Muhlenbergia racemosa	.	.	.	.	.	.	.	.	.	+.2	.	.
Poa arida	.	.	.	+.6	.	.	.	.	.	.	.	7.26
Poa interior	9.44	1.4	.	2.6	.	.	.	1.6	.	.	.	.
Poa palustris	.	.	.	1.8	.	.	.	1.4	4.18	.	.	.
Poa pratensis	.	.	.	.	.	.	.	.	.	13.32	.	2.4
Stipa comata	.	.	.	1.4	.	.	.	.	.	.	.	.
Stipa viridula	.	2.12	+.4	11.30	.	3.16	2.12	.	1.6	1.8	+.4	8.28
FORBS												
Achillea millefolia	7.36	3.14	.	+.4	1.2	.	.	.	1.2	2.16	.	4.32
Artemisia dracunculus	.	.	.	.	.	.	.	.	.	.	.	+.2
Artemisia ludoviciana	.	2.6	.	.	.	.	.	.	.	6.18	.	.
Aster oblongifolius	.	.	.	.	.	.	.	.	.	+.4	.	.
Astragalus agrestis	.	.	.	.	.	.	.	.	1.8	.	.	.
Chenopodium album	.	.	.	.	.	.	.	+.8	.	.	.	.
Convolvulus sepium	.	.	.	.	.	.	.	.	.	.	+.2	.
Conyza canadensis	.	.	.	.	.	.	1.12	.	.	.	3.28	.
Erigeron strigosus	.	.	.	.	.	.	+.4	.	.	.	.	.
Euphorbia podperae	.	+.6	.	.	.	.	.	.	.	.	.	.
Euphorbia spathulata	.	.	.	.	.	.	.	.	+.2	.	.	.
Galium aparine	.	+.4	.	.	.	.	.	1.8	.	.	.	.
Gaura coccinea	.	.	.	2.14	.	.	.	.	1.6	1.4	+.8	.
Grindelia squarrosa	.	.	.	.	+.2	.	.	.	.	.	.	.
Hedeoma hispida	.	.	.	.	.	.	.	+.2	+.2	.	.	.
Helianthus rigidus	.	.	.	.	.	.	.	.	+.2	.	.	.
Lactuca oblongifolia	.	.	.	11.38	+.2	.	.	1.16	10.54	.	.	.
Linum perenne	.	.	.	+.4	.	.	.	.	2.12	+.2	.	.
Melilotus officinalis	.	.	.	+.6	1.10	+.2	.	.	.	+.2	3.24	.
Monarda fistulosa	.	.	.	.	.	.	.	.	+.2	.	.	.
Mosses & Lichens	11.70	.	.	.	.	.	.	+.4	.	.	.	.
Opuntia fragilis	.	.	.	.	.	.	.	.	.	.	+.2	.
Opuntia polyacantha	.	+.2	.	.	.	.	.	.	.	.	.	.
Parietaria pennsylvanica	.	15.44	1.6	.	.	.	.	3.48	+.6	.	2.12	.
Plantago patagonica	.	.	.	.	.	.	.	.	.	.	+.4	.
Psoralea esculenta	.	.	.	6.24	.	.	.	.	.	.	.	.
Ratibida columnifera	.	.	.	+.2	.	.	1.4	.	+.6	.	.	.
Solidago missouriensis	.	.	.	.	.	.	.	.	.	.	2.4	.
Solidago rigida	.	.	.	.	.	.	.	.	1.2	.	.	.
Sphaeralcea coccinea	.	1.10	+.2	.	.	.	.	.	.	+.2	.	.
Taraxacum officinale	.	.	.	.	.	.	+.4	.	.	.	.	.
Thalictrum dasycarpum	.	.	.	.	.	.	.	.	.	1.4	.	.
Tragopogon dubius	.	.	.	.	.	.	+.2	.	.	.	.	.
Vicia americana	.	1.4	.	.	1.10	.	.	1.12	1.10	+.2	1.12	.
Species in microplots	5	14	8	20	8	6	10	13	23	18	16	12
Coverage of shrubs	24	52	27	36	34	26	42	95	74	79	65	95
Coverage of graminoids	88	83	90	102	95	99	100	40	97	63	71	90
Coverage of forbs	18	22	1	19	3	0	2	6	17	10	11	4
Total coverage	130	157	118	157	132	125	144	141	188	152	147	189

Table A7.—*Fraxinus pennsylvanica/Symphoricarpos occidentalis*, *Fraxinus pennsylvanica/Prunus virginiana*, and *Populus tremuloides/Betula occidentalis* habitat types

	Stand number											
	***Fraxinus/Symphoricarpos* H.T.**				***Fraxinus/Prunus* H.T.**				***Populus/Betula* H.T.**			
	29	**30**	**51**	**52**	**41**	**42**	**57**	**58**	**43**	**60**	**67**	**68**
Location												
Quarter section	**SE**	**SE**	**NW**	**SW**	**SW**	**SW**	**SE**	**NW**	**SW**	**NE**	**NW**	**SE**
Section	**16**	**16**	**31**	**31**	**11**	**11**	**21**	**27**	**35**	**32**	**11**	**3**
Township	**140N**	**140N**	**148N**	**148N**	**140N**	**140N**	**148N**	**148N**	**140N**	**148N**	**147N**	**147N**
Range	**102W**	**102W**	**99W**	**99W**	**102W**	**102W**	**100W**	**100W**	**101W**	**100W**	**100W**	**100W**
Topographic position												
Slope (%)	**0**	**11**	**2**	**0**	**0**	**3**	**6**	**14**	**77**	**13**	**23**	**48**
Aspect (°)	**0**	**28**	**24**	**0**	**0**	**283**	**340**	**25**	**30**	**73**	**341**	**320**
Elevation (m)	**683**	**683**	**600**	**600**	**710**	**707**	**732**	**728**	**838**	**753**	**765**	**759**
	Coverage/Frequency											
SHRUBS												
Amelanchier alnifolia	.	.	.	.	.	.	.	.	.	4.4	.	.
Arctostaphylos uva-ursi	.	.	.	.	.	.	.	.	.	.	.	*
Betula occidentalis	.	.	.	.	.	.	.	.	7.30	1.6	32.68	49.74
Celastrus scandens	.	.	.	.	.	.	.	.	+.2	1.8	+.2	+.2
Clematis ligusticifolia	+.4	.	1.4	2.12	+.2	1.10	.	+.2	.	.	*	+.4
Cornus stolonifera	.	.	+.2	.	.	.	.	.	1.2	+.2	.	2.4
Juniperus communis	1.12	+.6	.	.	.	.	.	.	1.20	.	.	+.2
Juniperus horizontalis	*	.	.	.	.	.	.	.	.	.	.	.
Parthenocissus vitacea	+.4	+.2	2.10	1.2	.	.	.	.	.	.	.	.
Potentilla fruticosa	.	.	.	.	.	.	.	.	*	.	.	.
Prunus virginiana	.	.	.	.	17.40	44.76	19.32	31.70	36.76	37.70	35.80	16.50
Rhus aromatica	11.32	3.8	1.2	8.18	+.2	3.4	.	.	+.2	.	.	.
Ribes odoratum	.	.	.	.	+.2	+.2	.	+.2	*	.	.	.
Ribes setosum	1.12	1.2	.	*	*	.	3.16	+.4	+.2	1.10	1.2	+.2
Rosa woodsii	1.8	2.10	9.56	13.50	2.8	16.50	.	.	+.6	+.6	3.22	.
Rubus idaenus	.	.	.	.	.	.	.	.	.	4.14	.	*
Salix bebbiana	.	.	.	.	.	.	.	.	*	.	.	.
Shepherdia argentea	+.2	1.4	*	.	.	.	.	.	9.28	.	.	.
Symphoricarpos albus	.	.	.	.	.	.	.	.	.	.	31.86	10.40
Symphoricarpos occidentalis	22.90	14.50	45.94	81.99	18.76	23.84	1.4	7.36	21.80	6.46	.	.
Toxicodendron rydbergii	17.62	2.14	61.99	12.28	+.2	*	.	.	30.82	6.46	21.76	+.4
Vitis vulpina	.	.	.	.	+.2	.	.	.	.	.	.	.
GRAMINOIDS												
Agropyron caninum	9.36	5.24	1.6	2.8	.	.	1.6	.	.	.	2.10	.
Bromus inermis	.	*	.	.	.	.	.	.	.	.	.	.
Calamovilfa longifolia	16.36	29.64	.	.	.	.	.	.	.	.	.	.
Carex sprengelii	.	+.2	.	.	.	.	52.88	70.92	.	25.44	9.18	.
Elymus canadensis	12.38	25.66	7.22	2.12	.	.	.	.	+.2	.	.	.
Elymus villosus	.	.	.	.	.	.	.	29.66	.	.	.	.
Elymus virginicus	.	.	.	.	38.96	41.90	30.90	1.2	1.6	.	.	.
Muhlenbergia racemosa	8.4	5.22	15.64	5.14	.	.	.	1.6	.	+.2	.	.
Oryzopsis micrantha	.	.	.	2.6	.	.	+.2	.	36.86	10.30	*	*
Poa paulstris	.	.	.	.	.	.	1.6	.	.	.	.	.
Poa pratensis	60.90	51.94	1.6	.	6.10	17.26	39.60	*	+.2	.	.	.
Schizachne purpurascens	.	.	.	.	.	.	3.10	.	.	.	.	.
Scirpus americanus	.	.	1.4	.	.	.	.	.	.	.	.	.
Stipa viridula	.	1.4	.	.	.	.	+.2	.	.	.	.	.
FORBS												
Achillea millefolium	.	.	.	*	.	*	+.6	.	1.12	+.2	*	.
Ambrosia psilostachya	.	1.10	2.12	.	.	.	.	.	.	.	.	.
Anemone cylindrica	.	.	+.2	.	.	.	*	1.2	+.6	.	.	.
Antennaria plantaginifolia	*	1.8	.	.	.	.	.	.	*	.	.	.
Apocynum androsaemifolium	.	.	.	.	.	.	.	.	*	33.72	12.42	1.4
Apocynum cannabinum	.	.	*	.	.	.	.	.	.	4.22	.	.
Aralia nudicaulis	.	.	.	.	.	.	.	.	.	.	20.64	.
Arctium minus	.	.	.	*	9.64	1.14	+.2 *	*	.	.	.	.

Table A7.—*Fraxinus pennsylvanica/Symphoricarpos occidentalis, Fraxinus pennsylvanica/Prunus virginiana,* and *Populus tremuloides/Betula occidentalis* habitat types—Continued

	Stand number											
	***Fraxinus/Symphoricarpos* H.T.**				***Fraxinus/Prunus* H.T.**				***Populus/Betula* H.T.**			
	29	**30**	**51**	**52**	**41**	**42**	**57**	**58**	**43**	**60**	**67**	**68**
Location												
Quarter section	**SE**	**SE**	**NW**	**SW**	**SW**	**SW**	**SE**	**NW**	**SW**	**NE**	**NW**	**SE**
Section	**16**	**16**	**31**	**31**	**11**	**11**	**21**	**27**	**35**	**32**	**11**	**3**
Township	**140N**	**140N**	**148N**	**148N**	**140N**	**140N**	**148N**	**148N**	**140N**	**148N**	**147N**	**147N**
Range	**102W**	**102W**	**99W**	**99W**	**102W**	**102W**	**100W**	**100W**	**101W**	**100W**	**100W**	**100W**
Topographic position												
Slope (%)	**0**	**11**	**2**	**0**	**0**	**3**	**6**	**14**	**77**	**13**	**23**	**48**
Aspect (°)	**0**	**28**	**24**	**0**	**0**	**283**	**340**	**25**	**30**	**73**	**341**	**320**
Elevation (m)	**683**	**683**	**600**	**600**	**710**	**707**	**732**	**728**	**838**	**753**	**765**	**759**
	Coverage/Frequency											
Artemisia ludoviciana	+.4	*	1.6	.	.	.	*	.	.	.	.	.
Ascelpias verticillata	.	.	*	.	.	.	.	.	.	.	.	.
Asparagus officinalis	*	*	.	.	.	.	.	.	.	.	.	.
Aster laevis	.	.	.	.	.	.	+.2	+.8	+.2	.	.	.
Astragalus agrestis	.	.	.	.	.	.	.	.	+.4	.	.	.
Campanula rotundifolia	.	.	.	.	.	.	.	.	+.4	.	+.2	.
Chenopodium album	.	.	.	.	+.6	+.6	.	.	.	.	.	.
Convolvulus arvensis	.	.	.	.	+.4	.	.	.	.	.	.	.
Convolvulus sepium	.	.	.	.	.	*	+.4	.	.	.	.	.
Disporum trachycarpum	.	.	.	.	.	.	.	1.4	2.26	+.2	4.32	15.86
Euphorbia podperae	+.2	.	.	.	.	.	.	.	.	.	.	.
Fragaria virginiana	.	.	.	.	.	.	.	3.40	1.10	.	4.60	1.16
Galium aparine	.	.	.	.	*	.	.	1.4	.	.	.	.
Galium boreale	4.10	.	.	4.28	19.74	3.14	12.76	7.56	5.34	8.46	7.38	+.2
Geranium carolinianum	.	.	.	.	.	.	*	.	.	1.4	.	.
Glycyrrhiza lepidota	.	.	2.10	.	.	.	.	.	.	.	.	.
Hackelia deflexa	.	.	.	.	+.2	.	.	.	.	.	.	*
Helianthus rigidus	.	.	+.4	.	.	.	.	.	.	.	.	.
Heuchera richardsonii	.	.	.	.	.	.	*	1.8	1.14	+.2	.	.
Lactuca oblongifolia	.	.	1.12	+.4	5.68	4.54	1.10	.	.	+.2	*	.
Linum perenne	.	*	.	.	.	.	.	.	.	.	.	.
Lygodesmia juncea	.	2.10	.	.	.	.	.	.	.	.	.	.
Medicago sativa	.	*	.	.	.	.	.	.	.	.	.	.
Melilotus albus	3.18	23.52	1.4	1.4	.	.	.	.	.	.	.	.
Melilotus officinalis	25.86	55.92	26.90	9.46	+.4	.	*	.	*	.	.	.
Monarda fistulosa	.	.	.	.	4.14	1.6	1.4	.	1.14	*	.	.
Mosses & Lichens	.	.	.	.	.	.	.	.	.	1.2	.	3.4
Osmorhiza longistylis	.	.	.	.	.	.	.	*	.	.	.	.
Oxalis stricta	.	.	.	.	1.10	1.16	1.8	+.2	.	.	.	.
Parietaria pennsylvanica	.	.	.	.	1.16	4.42	+.2	.	.	.	.	.
Polypodiaceae	.	.	.	.	.	.	*	+.8	1.14	4.6	.	.
Ranunculus abortivus	.	.	.	.	2.18	+.10	.	.	.	.	.	.
Ratibida columnifera	*	.	.	.	.	.	.	.	.	.	.	.
Sanicula marilandica	.	.	.	.	.	.	2.4	1.18	.	.	.	19.70
Smilacina stellata	+.8	3.18	+.8	1.10	.	.	1.10	2.30	7.46	6.56	2.30	+.6
Smilax herbacea	.	.	.	.	.	.	+.6	+.2	.	+.2	.	.
Solidago missouriensis	.	.	*	+.4	.	.	.	.	.	.	.	.
Solidago rigida	.	.	.	.	.	.	.	.	+.4	.	.	.
Taraxacum officinale	+.2	.	+.6	+.4	1.26	1.26	2.22	+.6	+.4	1.10	.	.
Thalictrum dasycarpum	*	.	*	.	2.18	3.22	*	*	.	.	+.2	.
Thalictrum venulosum	.	.	*	+.2	.	.	1.4	+.2	.	*	2.10	.
Thermopsis rhombifolia	.	.	+.2	.	.	.	.	.	1.8	.	.	.
Tragopogon dubius	+.2	.	.	.	.	.	2.10	+.2	.	.	+.2	.
Trifolium pratense	2.16	4.16	.	.	.	.	.	.	.	.	.	.
Urtica dioica	.	.	1.4	1.6	1.4	+.6	1.8	1.14	.	1.10	4.24	.
Vicia americana	1.8	*	+.4	.	.	.	.	.	.	.	.	.
Viola pratincola	+.12	+.4	+.2	+.4	.	.	.	.	.	.	.	.
Viola sp.	.	.	.	.	.	.	+.2	.	+.2	.	.	.
Species in microplots	25	26	26	20	24	19	28	25	31	27	20	16
Coverage of shrubs	53	23	119	112	37	87	23	38	106	60	123	77
Coverage of graminoids	105	116	25	11	44	58	126	101	37	35	11	0
Coverage of forbs	35	89	34	16	45	29	24	18	20	59	55	39
Total coverage	193	228	178	139	126	164	173	157	163	154	189	116

Table A8.—*Juniperus scopulorum/Oryzopsis micrantha* habitat type

	Stand number						
	33	34	37	38	49	50	53
Location							
Quarter section	**SW**	**SW**	**NW**	**SE**	**SW**	**SW**	**NE**
Section	**11**	**11**	**24**	**23**	**30**	**30**	**25**
Township	**140N**	**140N**	**140N**	**140N**	**148N**	**148N**	**148N**
Range	**101W**	**101W**	**101W**	**101W**	**99W**	**99W**	**100W**
Topographic position							
Slope (%)	**45**	**65**	**42**	**38**	**47**	**67**	**64**
Aspect (°)	**332**	**2**	**296**	**11**	**304**	**294**	**358**
Elevation (m)	**817**	**792**	**786**	**826**	**634**	**655**	**652**
	Coverage/Frequency						
SHRUBS							
Artemisia cana	.	.	.	.	.	*	.
Artemisia frigida	*	.	+.4	*	.	*	*
Artemisia tridentata	+.2	.	.	.	.	+.2	+.2
Ceratoides lanata	.	.	.	.	.	.	*
Chrysothamnus nauseosus	.	.	+.2	*	.	*	.
Clematis ligusticifolia	.	.	.	*	.	.	*
Gutierrezia sarothrae	.	.	.	.	.	.	*
Potentilla fruticosa	+.2	.	.	.	.	.	.
Prunus virginiana	48.50	*	14.44	4.22	6.22	+.2	2.8
Rhus aromatica	11.36	+.2	12.36	2.10	2.8	3.6	+.6
Ribes odoratum	+.2	2.4	*	*	.	.	.
Ribes setosum	.	1.2	*	.	.	*	.
Rosa arkansana	+.4	.	.	.	.	.	.
Rosa woodsii	+.6	*	1.6	1.4	*	*	.
Symphoricarpos occidentalis	+.8	3.10	3.34	2.20	4.24	1.8	+.12
GRAMINOIDS							
Agropyron caninum	+.4	+.2	+.2	5.26	+.2	+.2	*
Carex eburnea	.	.	.	.	.	6.10	4.8
Oryzopsis micrantha	59.99	62.99	68.99	68.98	59.96	77.99	76.99
Poa pratensis	.	.	.	.	.	.	+.2
Stipa viridula	.	.	*	.	.	.	.
FORBS							
Achillea millefolium	+.12	+.8	2.22	+.8	+.2	+.6	+.8
Anemone patens	.	.	*	.	*	*	+.6
Antennaria rosea	*	+.2	+.2	*	+.4	+.6	+.12
Astragalus adsurgens	.	.	.	+.6	*	.	.
Campanula rotundifolia	+.2	+.4	1.16	1.18	+.12	3.32	3.28
Chenopodium album	*	.	.	+.2	.	.	.
Fragaria virginiana	+.2	.	+.2	.	.	.	.
Galium boreale	5.60	4.34	3.72	5.68	5.66	3.40	7.72
Gentianella amarella	*	+.2	+.4	.	.	.	1.14
Geum triflorum	.	*	.	.	*	+.2	.
Hackelia deflexa	+.6	.	*	*	.	.	.
Heuchera richardsonii	+.4	*	*	*	+.2	*	*
Linum perenne	.	.	.	.	*	.	.
Melilotus officinalis	.	.	.	.	*	*	.
Mirabilis linearis	.	.	.	+.6	.	.	.
Monarda fistulosa	1.4	.	.	.	.	*	.
Mosses & Lichens	78.99	92.99	91.99	37.80	78.99	69.99	61.98
Opuntia fragilis	.	*	.	.	.	*	*
Opuntia polyacantha	.	.	.	*	.	.	*
Oxytropis campestris	.	.	+.2	.	.	.	.
Oxytropis lambertii	.	1.4	.	.	*	.	+.2
Parietaria pennsylvanica	.	*	.	.	*	.	.
Polypodiaceae	*	2.40	1.22	1.20	1.18	1.8	7.76
Potentilla pensylvanica	.	.	*	.	.	.	.
Selaginella densa	.	*	.	.	.	.	.
Smilacina stellata	2.18	+.2	1.12	+.4	1.10	*	1.10
Solidago missouriensis	+.2	.	*	+.6	.	.	1.6
Taraxacum officinale	*	.	+.10	+.10	+.10	+.6	+.6
Tragopogon dubius	.	.	*	+.2	.	.	.
Vicia americana	.	.	.	.	.	+.2	.
Viola adunca	.	.	+.6	1.20	+.6	1.28	+.14
Viola sp.	.	*	.	.	.	.	.
Species in microplots	20	15	19	19	15	17	20
Coverage of shrubs	59	6	30	9	12	4	2
Coverage of graminoids	59	62	68	73	59	83	80
Coverage of forbs	86	99	99	45	85	77	81
Total coverage	204	167	197	127	156	164	163

Table A9.—*Symphoricarpos occidentalis* community type

	Stand number				
	11	17	19	45	59
Location					
Quarter section	**NW**	**NE**	**SE**	**SE**	**NW**
Section	**23**	**33**	**28**	**29**	**28**
Township	**140N**	**141N**	**141N**	**147N**	**148N**
Range	**102W**	**101W**	**101W**	**100W**	**100W**
Topographic position					
Slope (%)	**11**	**8**	**3**	**4**	**6**
Aspect (°)	**335**	**347**	**165**	**18**	**160**
Elevation (m)	**707**	**716**	**704**	**719**	**719**
	Coverage/Frequency				
SHRUBS					
Artemisia cana	.	+.2	.	.	.
Artemisia frigida	.	+.4	.	.	.
Prunus americana	.	.	1.2	.	.
Prunus virginiana	.	.	3.4	.	.
Ribes odoratum	6.8	.	.	.	.
Rosa woodsii	37.60	2.8	2.10	+.2	.
Symphoricarpos occidentalis	89.99	85.99	95.99	98.99	98.99
GRAMINOIDS					
Agropyron caninum	.	1.6	11.22	1.4	.
Agropyron smithii	15.28	63.82	10.20	1.2	.
Andropogon gerardii	.	.	.	.	1.6
Bromus inermis	*	.	6.6	.	.
Bromus tectorum	.	.	.	+.6	.
Carex filifolia	.	+.2	.	.	.
Elymus virginicus	.	.	1.6	.	.
Koeleria pyramidata	.	+.2	.	.	.
Poa pratensis	.	.	64.86	6.22	21.46
Stipa viridula	.	1.8	.	.	.
FORBS					
Achillea millefolium	+.2	2.12	+.6	.	+.2
Artemisia ludoviciana	9.24	2.12	1.14	1.16	3.14
Astragalus agrestis	.	8.42	.	.	.
Chenopodium album	.	.	+.2	+.2	.
Convolvulus arvensis	1.4	.	+.2	4.20	.
Convolvulus sepium	.	.	.	.	1.8
Galium aparine	+.2	.	+.2	+.6	.
Galium boreale	.	.	6.16	8.24	10.42
Hackelia deflexa	.	.	.	.	+.2
Humulus lupulus	.	.	9.14	.	.
Lactuca oblongifolia	11.44	1.22	38.90	+.2	.
Linum perenne	.	2.18	.	.	.
Linum rigidum	+.2	.	.	.	.
Medicago sativa	.	.	.	+.2	.
Parietaria pennsylvanica	5.16	7.24	1.8	4.8	+.4
Ratibida columnifera	+.2	.	.	.	.
Sisymbrium altissimum	.	.	.	+.2	.
Taraxacum officinale	+.6	.	+.2	+.4	.
Thalictrum venulosum	.	.	.	.	+.2
Urtica dioica	.	.	+.2	.	.
Species in microplots	14	15	20	16	10
Coverage of shrubs	132	87	101	98	98
Coverage of graminoids	15	65	92	8	22
Coverage of forbs	26	22	55	17	14
Total coverage	173	174	248	123	134

APPENDIX 2. TREE POPULATION ANALYSES

Population structure of trees in stands, by habitat types. Numbers of trees listed per 375 m^2, with basal area for the stand as m^2/ha given below the stand number. Abbreviations of tree species are as follows:

ACNE—*Acer negundo*
CRCH—*Crataegus chrysocarpa*
FRPE—*Fraxinus pennsylvanica*
JUSC—*Juniperus scopulorum*
PODE—*Populus deltoides*
POTR—*Populus tremuloides*
ULAM—*Ulmus americana*

Table A10.—Population structure of trees in stands, by habitat type

Stand and b.a.	Spp.	Diameter (at breast height) classes in dm						
		0-1		1-2	2-3	3-4	4-5	5-6	6-7
		<.5	>.5						
	1. *Fraxinus pennsylvanica/Symphoricarpos occidentalis* habitat type								
29	FRPE	56							
39.5	JUSC	20	6	15					
	PODE						4	5	
30	FRPE	5							
23.3	JUSC	20	4	2	1				
	PODE						3	3	
51	FRPE	513	31	2					
63.1	JUSC	33	1	5					
	PODE							3	4
52	FRPE	489	8						
39.5	JUSC	6	9	4	1				
	PODE				4	3	3	1	
	2. *Fraxinus pennsylvanica/Prunus virginiana* habitat type								
41	FRPE	332	20	28	5				
23.8	JUSC	6		1					
42	FRPE	306	11	12	8	1			
21.6	JUSC			1					
57	FRPE	15	5	17	9	4			
35.9	ULAM	66			2	1			
	JUSC	2							
58	FRPE	5	1	15	3				
25.1	ULAM	21	8	15	4				
	ACNE	8	1	1					
	JUSC	2							
	3. *Populus tremuloides/Betula occidentalis* habitat type								
43	POTR	81	58	9					
14.7	FRPE	47	10	2					
	JUSC	7							
60	POTR	82	35	28	1				
21.1	FRPE	41							
	ULAM	9	1	2					
	CRCH	1							
67	POTR	136	15	32					
20.9	FRPE	61	6	2					
	JUSC	1							
68	POTR	22	2	17	22				
41.8	FRPE	92	5	6					
	ACNE	13	5						
	4. *Juniperus scopulorum/Oryzopsis micrantha* habitat type								
33	JUSC	47	21	20	1	3			
29.6	FRPE	62	15	5					
34	JUSC	126	60	30	1				
23.4									
37	JUSC	112	82	24					
22.1	FRPE	17	1						
38	JUSC	98	86	30					
25.4	FRPE	6							
49	JUSC	207	108	10	2				
22.2	FRPE	1							
50	JUSC	158	43	26	4				
22.7	FRPE	2							
53	JUSC	232	59	21	3				
22.4	FRPE	10							

APPENDIX 3. SOIL ANALYSES

Table A11.—Results of soil analyses of the upper 1 dm of mineral soil from each stand. Data are arranged according to habitat types

Stand	pH	C.E.C. (meq/ 100 g)	Free lime[1]	Extractable cations (meq/100 g)			P	N	O.M.[2]	Mechanical analysis (percent)			Texture
				Ca	Mg	Na	(ppm)	(%)	(%)	Sand	Silt	Clay	
Stipa comata/Carex filifolia habitat type													
27	6.2	-	-	-	-	-	-	0.174	2.6	56.4	34.0	9.6	Sandy loam
35	6.9	-	-	-	-	-	-	0.116	1.8	64.4	29.6	6.0	Sandy loam
36	6.7	6.84	-	7.65	3.58	0.14	4.5	0.097	2.0	71.4	22.6	6.0	Sandy loam
39	7.5	6.47	+	16.67	3.54	0.18	3.0	0.107	1.4	74.0	18.0	8.0	Sandy loam
40	7.1	-	-	-	-	-	-	0.073	1.0	79.0	13.0	8.0	Loamy sand
56	7.1	-	-	-	-	-	-	0.114	1.6	53.6	35.6	10.8	Sandy loam
61	6.8	9.61	+	51.10	1.73	0.07	4.0	0.081	1.3	86.0	7.6	6.4	Loamy sand
Agropyron smithii/Carex filifolia habitat type													
3	7.7	-	-	-	-	-	-	0.159	2.4	32.4	45.0	22.6	Loam
5	7.7	-	-	-	-	-	-	0.180	2.6	39.4	40.0	20.6	Loam
14	7.6	18.38	+ + +	39.05	2.47	0.12	0.5	0.178	2.7	38.8	37.6	23.6	Loam
18	7.7	13.83	+ + +	26.66	3.98	0.10	0.5	0.178	2.4	45.2	35.2	19.6	Loam
20	7.7	-	-	-	-	-	-	0.171	2.2	50.4	32.0	17.6	Loam
21	7.7	-	-	-	-	-	-	0.149	2.0	43.4	40.6	16.0	Loam
48	7.6	-	-	-	-	-	-	0.153	1.8	50.0	36.0	14.0	Loam
54	6.7	28.47	-	11.54	4.79	0.11	1.0	0.181	2.1	44.0	41.0	15.0	Loam
62	7.6	-	-	-	-	-	-	0.137	2.0	35.0	40.6	24.4	Loam
Andropogon scoparius/Carex filifolia habitat type													
8	7.7	-	-	-	-	-	-	0.164	2.6	66.4	26.0	7.6	Sandy loam
15	7.7	9.07	+ + +	26.05	1.35	0.11	0.5	0.158	2.1	61.2	31.2	7.6	Sandy loam
22	7.7	-	-	-	-	-	-	0.237	3.0	34.4	49.6	16.0	Loam
23	7.7	14.11	+ +	30.01	3.12	0.15	3.0	0.190	2.4	48.4	41.6	10.0	Loam
24	7.7	-	-	-	-	-	-	0.155	2.2	52.4	40.0	7.6	Sandy loam
46	7.7	-	-	-	-	-	-	0.154	2.1	22.6	55.0	22.4	Silt loam
55	7.8	-	-	-	-	-	-	0.087	1.1	23.6	49.6	26.8	Loam
63	7.6	-	-	-	-	-	-	0.142	2.0	57.0	28.6	14.4	Loam
64	7.6	11.32	+ + +	24.45	3.51	0.07	0.5	0.123	1.8	48.4	38.6	13.0	Loam
Juniperus horizontalis/Andropogon scoparius habitat type													
9	7.6	-	-	-	-	-	-	0.112	2.4	40.4	37.4	22.2	Loam
10	7.6	17.88	+ + +	54.16	3.30	0.25	0.5	0.232	3.4	26.4	44.0	29.6	Clay loam
12	7.4	26.67	+ +	34.03	2.74	0.04	1.0	0.219	3.0	48.8	29.6	21.6	Loam
44	7.3	39.13	+	36.89	6.37	0.27	2.0	0.274	4.2	48.0	41.0	11.0	Loam
47	7.5	-	-	-	-	-	-	0.138	2.5	37.6	34.0	28.4	Clay loam
Artemisia tridentata/Agropyron smithii habitat type													
4	7.4	26.42	+	43.17	6.97	1.57	6.0	0.147	3.6	23.0	35.4	41.6	Clay
13	7.1	-	-	-	-	-	-	0.146	3.5	24.8	71.6	3.6	Silt loam
16	7.5	10.31	+	20.45	5.81	0.71	2.0	0.165	2.2	39.2	35.2	25.6	Loam
28	7.6	31.02	+ + +	32.04	4.61	1.30	1.0	0.177	2.5	26.0	41.6	32.4	Clay loam
Artemisia cana/Agropyron smithii habitat type													
1	7.8	15.98	+ + +	39.22	2.69	2.61	2.5	0.100	1.8	18.4	50.0	31.6	Silty clay loam
6	7.8	-	-	-	-	-	-	0.157	2.0	14.4	50.0	35.6	Silty clay loam
7	7.8	-	-	-	-	-	-	0.137	1.9	13.4	52.0	34.6	Silty clay loam
26	7.7	-	-	-	-	-	-	0.098	2.9	40.4	46.6	13.0	Loam
66	8.0	-	-	-	-	-	-	0.069	1.7	17.8	63.6	18.6	Silt loam
69	7.8	11.31	+ + +	23.61	3.21	1.11	24.0	0.071	1.4	13.8	61.6	24.6	Silt loam
70	7.7	-	-	-	-	-	-	0.046	1.7	58.8	29.6	11.6	Sandy loam
2	7.6	11.22	+ + +	33.52	2.42	0.11	1.0	0.101	2.1	38.4	29.0	32.6	Clay loam
25	7.6		-	-	-	-	-	0.098	2.2	34.4	47.6	18.0	Loam
31	7.7	8.82	+ + +	20.18	3.39	0.25	0.5	0.082	2.0	38.0	42.0	20.0	Loam
32	7.7		-	-	-	-	-	0.055	1.6	36.0	54.0	10.0	Silt loam
65	7.6	-	-	-	-	-	-	0.088	3.6	34.8	50.6	14.6	Silt loam
Fraxinus pennsylvanica/Symphoricarpos occidentalis habitat type													
29	7.6	17.57	+ +	21.13	3.13	0.31	2.5	0.138	2.6	31.0	51.0	18.0	Silt loam
30	7.6	-	-	-	-	-	-	0.089	1.7	44.0	41.0	15.0	Loam
51	7.5	28.21	+ +	30.31	6.42	0.59	1.0	0.152	2.6	31.0	35.0	34.0	Clay loam
52	7.5	17.14	+	27.91	6.61	0.23	2.0	0.155	3.4	22.0	50.6	27.4	Clay loam

Table A11.—Results of soil analyses of the upper 1 dm of mineral soil from each stand. Data are arranged according to habitat types—Continued

Stand	pH	C.E.C. (meq/100 g)	Free lime[1]	Extractable cations (meq/100 g)			P	N	O.M.[2]	Mechanical analysis (percent)			Texture
				CA	Mg	Na	(ppm)	(%)	(%)	Sand	Silt	Clay	
						Fraxinus pennsylvanica/Prunus virginiana habitat type							
41	7.6	–	–	–	–	–	–	0.202	2.9	33.0	33.0	34.0	Clay loam
42	7.6	15.25	+ + +	32.23	4.97	0.25	0.5	0.154	2.5	15.0	39.0	46.0	Clay
57	6.0	25.53	–	18.52	6.83	0.12	9.5	0.362	4.1	34.6	45.6	19.8	Loam
58	6.4	24.83	–	17.72	3.89	0.10	9.5	0.406	3.6	38.0	43.2	18.8	Loam
						Populus tremuloides/Betula occidentalis habitat type							
43	7.2	12.94	–	13.56	4.89	0.13	3.0	0.099	2.3	35.0	39.0	26.0	Loam
60	5.7	–	–	–	–	–	–	0.221	3.3	48.0	34.6	17.4	Loam
67	6.0	18.23	–	13.98	6.05	0.08	9.0	0.111	1.9	64.4	24.0	11.6	Sandy loam
68	7.1	16.66	–	12.53	4.06	0.11	1.0	0.103	1.6	32.8	39.6	27.6	Clay loam
						Juniperus scopulorum/Oryzopsis micrantha habitat type							
33	6.7	–	–	–	–	–	–	0.295	4.3	57.0	33.0	10.0	Sandy loam
34	7.9	17.58	+ + +	27.62	8.10	1.57	0.5	0.130	2.3	25.0	39.0	36.0	Clay loam
37	7.8	–	–	–	–	–	–	0.167	3.0	27.0	34.0	39.0	Clay loam
38	7.6	30.91	–	19.43	13.91	3.55	0.5	0.203	3.3	31.0	30.0	39.0	Clay loam
49	7.6	–	–	–	–	–	–	0.180	3.0	26.0	39.0	35.0	Clay loam
50	7.8	–	–	–	–	–	–	0.149	3.3	35.0	36.0	29.0	Clay loam
53	7.8	23.09	+	25.80	8.22	1.32	0.5	0.164	2.6	44.0	32.0	24.0	Loam
						Symphoricarpos occidentalis community type							
11	7.4	–	–	–	–	–	–	0.259	3.1	45.8	28.6	25.6	Loam
17	7.5	15.93	+ + +	28.11	2.90	0.17	2.5	0.222	3.0	47.2	31.2	21.6	Loam
19	7.5	–	–	–	–	–	–	0.341	4.2	18.0	48.0	34.0	Silty clay loam
45	6.2	23.90	–	16.43	5.92	01.0	2.5	0.286	3.4	32.4	45.6	22.0	Loam
59	5.8	–	–	–	–	–	–	0.273	3.3	35.0	46.2	18.8	Loam

[1]*Free lime determined subjectively. + = low, + + = medium, + + + = high.*
[2]*Organic matter.*

Table A12.—Gravel content (percent by weight) of soil samples taken from the upper 1 dm of mineral soil from each stand

Habitat type	Stand	Gravel content
Stipa comata/Carex filifolia	61	11.4
Andropogon scoparius/Carex filifolia	22	6.7
Andropogon scoparius/Carex filifolia	23	36.2
Andropogon scoparius/Carex filifolia	24	30.3
Juniperus horizontalis/Andropogon scoparius	10	6.5
Juniperus horizontalis/Andropogon scoparius	44	29.2
Artemisia tridentata/Agropyron smithii	28	4.6
Artemisia cana/Agropyron smithii	2	16.0

Hansen, Paul L., George R. Hoffman, and Ardell J. Bjugstad. 1984. The vegetation of Theodore Roosevelt National Park, North Dakota: A habitat type classification. General Technical Report RM-113, 35 p. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colo.

Vegetation of the Theodore Roosevelt National Park, North Dakota, was characterized according to habitat type based on concepts and methods developed by Daubenmire. Ten habitat types—three grassland and seven wooded types—were described including a key to identify the habitat types.

Keywords: Vegetation classification, habitat type, *Stipa comata, Carex filifolia, Andropogon scoparius, Juniperus horizontalis, Artemisia tridentata, Agropyron smithii, Artemisia cana, Fraxinus pennsylvanica, Symphoricarpos occidentalis, Prunus virginiana, Populus tremuloides, Betula occidentalis, Juniperus scopulorum, Oryzopsis micrantha*

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Rocky Mountains

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U.S. Department of Agriculture
Forest Service

Rocky Mountain Forest and Range Experiment Station

The Rocky Mountain Station is one of eight regional experiment stations, plus the Forest Products Laboratory and the Washington Office Staff, that make up the Forest Service research organization.

RESEARCH FOCUS

Research programs at the Rocky Mountain Station are coordinated with area universities and with other institutions. Many studies are conducted on a cooperative basis to accelerate solutions to problems involving range, water, wildlife and fish habitat, human and community development, timber, recreation, protection, and multiresource evaluation.

RESEARCH LOCATIONS

Research Work Units of the Rocky Mountain Station are operated in cooperation with universities in the following cities:

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Flagstaff, Arizona
Fort Collins, Colorado*
Laramie, Wyoming
Lincoln, Nebraska
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*Station Headquarters: 240 W. Prospect St., Fort Collins, CO 80526